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Field artillery instruction

Arthur Hazleton Carter, Archibald Vincent Arnold

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Field Artillery Instruction

A Complete Manual of Instruction for Prospective Field Artillery Officers

By

Arthur H. Carter

Formerly Colonel, Field Artillery, U. S. A.
Commandant of the Field Artillery Central Officers Training School
Camp Zachary Taylor, Kentucky

and

Archibald V. Arnold

Captain, Field Artillery, U. S. A.
Formerly Senior Instructor of the Field Artillery Central Officers Training School

With 272 Illustrations

G. P. Putnam's Sons
New York and London
The Knickerbocker Press
1920

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PREFACE

THE necessity for a compilation and explanation of the various subjects vital to a beginner in Field Artillery was brought out during the existence of the Field Artillery Central Officers Training School, Camp Zachary Taylor, Kentucky, where many thousands of the highest type of Americans were brought together for intensive training as candidate Field Artillery officers. Most careful thought and attention was given to their course of instruction; the experience gained there showed clearly the need of condensation of the subjects taught. There are in existence numerous books, pamphlets, training circulars, memoranda, drill regulations, etc., which if available and properly selected would cover very well all the needs of a Field Artillery officer.

The beginner in time of war rarely has sufficient time at his disposal to cover the various sources of information. Likewise the Civilian Enthusiast, Reserve Officer, Member of an R. O. T. C. Unit, or Militia Officer, is limited by his business or other obligations in time available for research or study.

This book is intended to fill the need of such men, to guide them in a logical line of study, and to give the maximum benefit possible in a single volume. Much of the material has been obtained from various government and other publications. Thanks are due to all the officers of the Instruction Department and Staff of the F. A. C. O. T. S. for valuable assistance in compiling the data. The original compilation, in somewhat different form and sequence, was known as the F. A. C. O. T. S. Black Book.

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Field Artillery Instruction

CHAPTER I

PHYSICAL INSTRUCTION

THE Manual of Physical Training should be thoroughly studied and closely followed. Physical drill is one of the most vital parts of the soldier's instruction. It is difficult to conduct properly because physiology, psychology, and the work in hand must be understood to make it effective. It is vital because it is the A, B, C, of a soldier's training on which he is started right or wrong for the work to follow. The instructor must have force, enthusiasm, appreciation of his subject, and the ability to command respect.

The objects of physical training are health, physical ability, self-reliance, and discipline. The first is obtained through the development of the soldier's power of resistance. This comes with pure blood and a strong heart. The second is obtained through practicing those things which are physically similar to the ordinary activities of the soldier. Games and athletics in general develop physical ability better than calisthenics, because in the former a man is taught to respond to a situation while in the latter he responds to a command. Self-reliance comes through consciousness of the ability to do. Discipline is obtained best through the calisthenics. It can be considered in two phases—the officers' discipline of the men, and the men's discipline of themselves. The latter is the more important because it involves mental as well as physical self-control.

The best formation for physical drill is one in which the men are separated far enough to exercise, yet are as near the instructor's voice and eye as possible. Such a formation is gained by the following commands:

From a column of squads: (1) **"Extend to the right and left; (2) MARCH."** Number two file stands fast, raising arms sideward as one and three clear. Others with arms raised sideward sidestep in

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quick time away from number two until the ends of their fingers no longer touch. (1) **"Rear rank right-step two steps, (2) MARCH."** This enables the rear rank men to cover the interval between the front rank men. (1) **"Arms, (2) DOWN."** Face them either to the right or left, being governed by the wind and the sun. The ideal condition is to have the wind at the instructor's back so that his voice carries well and the sun at his side so that it is neither in his eyes nor those of the class. From the middle of the forenoon to the middle of the afternoon, give first consideration to the wind. At other times in arranging the class consider the sun first.

Accuracy in the starting positions should be insisted upon. In correcting and judging an exercise during its progress, the starting positions and the points of momentary pause should be watched. If these points are reached just an instant late each time, or a little behind the count, the instructor should raise the pitch of his voice in counting. If there is a tendency to speed up an exercise, lowering the pitch of the voice will hold it in check. In giving commands regard must be had for inflection, tone, pronunciation, and emphasis. Men in groups are controlled by their feelings, not their reason. Their feelings are influenced by the tone of the command rather than by the words used. The words of a command must be correctly pronounced. Each word must be given its proper emphasis. Preparatory commands contain only words that are essential to the execution of the exercise. None of them can be slurred over without impairing the efficiency of the command.

Instructors must be enthusiastic or the men will get very little out of the work. The instructor need not stand at attention when he gives the commands but he must always show an attitude of attention both in voice and physical appearance. He must show that he enjoys doing the work himself. He must lead, not drive.

A class in calisthenics must not be worked violently in the first few exercises. The heart must be warmed up to its task gradually before heavy work is put upon it. Start with the smaller muscles and gradually work up with the larger ones to top speed in exercising. The use of all muscles in a general exercise should come towards the end of the period.

The cadence of trunk and neck exercises should not be too fast. There is danger in trying to put "snap" into such exercises. The exercises that bend the trunk directly backward should be used with caution. Such exercises badly given develop an undesirable curve in the back, and weaken the back and the muscles of the trunk generally. Nature has provided a natural curve for the back that must not be interfered with.

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When improperly given breathing exercises are dangerous. They seriously interfere with the circulation and therefore the heart action. Properly given they are beneficial and are a useful part of normal physical exercise. For instance, when the men slump into unhygienic positions after exercising, a breathing exercise is proper. In this case the exercise should be given "by the numbers," at a rate as near the average breathing rate as possible. There should be a slight pause between exhaling and inhaling to allow for the difference in breathing rates. Holding the breath with lungs inflated is injurious. Simply inflate to capacity, then let it out. Do not use extra force on the air in either direction.

The exercises are done either "in cadence" or "by the numbers." "By the numbers" or "by command" is used in stretching exercises, breathing exercises, exercises in which the positions are to be corrected, and in any exercise given for the disciplinary effect. All other exercises are done in cadence. There is value to cadence or rhythm in motion. Men on the march can cover an extra mile without feeling the fatigue if they are stepping in cadence. The same applies to physical exercises. **"In cadence"** is the preparatory command. **"EXERCISE"** is the command of execution. There is one number for each separate movement of the exercise, and that number comes at the *end* of the movement for which it stands. **"By the numbers"** is the preparatory command, and **"EXERCISE"** is again the command of execution, but in this case the numbers come before the movement for which they stand, for each is a command of execution. In starting the exercise "by the numbers" the first count "one" is left out because the command of execution is "Exercise." It is an error to drop into cadence with an exercise after having started it by the numbers.

If an exercise can be done in the cadence of quick time, it will not be necessary to do more than give the preparatory command, but if the cadence is to be very different or unusual announce it by illustration before the exercise is started. In illustrating and leading an exercise move in the direction the class will take in executing the exercise. Facing the class and giving the exercise to lunge to the right, the leader must lunge to his left.

When an exercise is given for the first time, move the men to each position by command, and hold them in that position while you correct them. Then having brought them back to the starting position, begin your exercise by announcing the number of counts, cadence, and the command "Exercise."

For example:

(1) **Arms forward**, (2) **RAISE** (here the instructor sees that they

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all have the correct position, making any corrections or suggestions necessary; but they must be brief and to the point).

(1) **Arms,** (2) **DOWN** (here the instructor cautions against slapping the thighs or simply letting the arms fall back to their position. The arms should be brought smartly back to the position of attention—not an inch further nor an inch less): Then the instructor commands: **"Take that exercise in two counts:** (1) **In cadence,** (2) **EXERCISE** one, two, one, two,—one, two, and **HALT."**

If the exercise is one with which the men are familiar, the instructor starts it by commanding: (1) **"Arms forward,** (2) **RAISE.** Swing arms downward and forward; two counts, (1) **In cadence,** (2) **EXERCISE."**

Care must be taken to follow the sequence of the lessons; *i. e.*, first starting positions, then the arm, leg, neck, and trunk exercises, in that order, followed by a general exercise that gets all muscles at once. Repeat this as many times as necessary to fill up the period, but keep to the sequence. Use all the exercises you have in the assigned lessons before drawing on previous lessons. The battery must be taught a variety of exercises, as the men become stale and lose interest when the same ones are given every day.

The following bracing exercises are recommended:

From arms forward, stretch arms sideward, turning palms upward.

Arms sideward, rotate arms turning palms upward and backward.

From attention, rotate arms backward, at the same time moving shoulders backward.

Arms to thrust; move shoulders forward, upward, backward, and down.

Arms to thrust; move head directly backward keeping the chin down in its same plane.

Arms to thrust; move fists outward, keeping forearms in the same horizontal plane.

Hands laced behind head; full bend trunk forward, keeping elbows well back, eyes to the front, back straight.

In all these exercises the back must be kept straight by pushing the buttocks forward, hips back, and drawing the stomach up. To attain an erect soldierly bearing, the position must be kept continually until it becomes a habit.

The jumping exercises can be done best from battery in line. Indicate the desired jump or jumps. Then jump them successively by commanding:

"All number one's, (1) **Ready,** (2) **JUMP.** Number two's, (1)

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Ready, (2) JUMP," and so on until you have jumped front rank, then rear rank. Immediately upon taking the indicated jumps they move four paces directly to the front and reform the battery facing in the same way. Give them **"ABOUT FACE"** and jump them back across the same ground in the reverse order. Only a small space is necessary for several good, healthy jumps.

Besides the games and contests found in the back of the Manual of Physical Training there are innumerable games from schoolyard and playground to draw on. A half-dozen books of such games may be found in any good library. The simplest games are the best. They must be group games that a great many can play at one time and that all can understand readily. These games develop health and real physical ability. The calisthenics give discipline and aid in developing a good "set-up" but the games and contests give the practical physical training.

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CHAPTER II

DISMOUNTED DRILL AND MILITARY COURTESIES

Dismounted Drill

ONE of the strongest aids to discipline that the Artilleryman has is Dismounted Drill. The movements are precise and exact and the execution follows immediately a word of command. Each man's body must go through a certain sequence of movements accurately and in accordance with the will of the instructor. The man learns to control his body and make it do as he wishes; discipline of the body. He also becomes accustomed to obeying commands immediately and exactly, discipline of the mind. A battery well schooled in Dismounted Drill has a good foundation in discipline. The various drills the Artilleryman must learn can be easily taught and can be carried out with precision and snap.

Dismounted Drill when well given will be interesting, but it can be just the reverse when the officer conducting the drill does not understand how to lead. A schedule should be made and followed just as in other kinds of artillery drill. It requires on the part of the officer the expression of life, energy, and snap in carriage and voice at every moment while actively engaged in the drill. This spirit should be so strongly shown that the men in ranks will be infected with it and will be led to put forth their best efforts in mastering the manner of execution of the drill. He must not relax for one moment his efforts to make the exercise interesting and fascinating for the men he is drilling.

In the drill of the entire battery in order to keep the men going at maximum speed, frequent changes in the squads should be made. After two or three minutes' drill halt the battery in line, face it about, and give the command, **"COUNT OFF."** This changes the front and rear rank and each man must know the movements of each number of the squad in order to keep up with the drill. By the command, **" (1) No. 1 on the left of the squad, (2) FALL IN; No. 2 on the right (left) of the squad, FALL IN,"** and so on for Nos. 3 and 4, the squad can be changed completely and by counting off and

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drilling the interest can be kept at a high pitch. Combinations of these changes will keep every man on his toes and will keep the drill from dragging. A third suggestion is to caution the battery to obey only commands prefixed by the expression "Murphy says" or one similar. Drill the battery using ordinary commands and commands prefixed by the key expression. By causing each man who errs to pay for his error by running a certain fixed course the battery can be given more exercise and the interest and attention heightened.

A final caution: while at drill radiate energy and snap in body, voice, and movement.

Military Courtesies

Of late years there has been much criticism of the military custom of saluting. These critics lose sight of the origin of saluting and fail to realize that its significance is as honorable to-day.

The salute rises from the old custom of free men, who alone were permitted to carry arms, greeting each other with the right hand raised to the visor to show that they were unarmed. Slaves did not salute. It is the same to-day. Salutes are only rendered between free military men who should be proud of the fact that they are physically and mentally able to bear arms for their country. As one officer said, "When I salute I think I'm a doggone son-of-a-gun good fighting man and you're another."

The salute and discipline cannot be separated. Without discipline an army becomes a mob. As General Sherman said "Discipline is the souls of armies." It will be remembered that shortly before the Russian debacle the salute was dispensed with. It is said that early in the late war a certain division was almost annihilated, not because of lack of bravery or leadership but because of lack of discipline. Before this division again returned to the front it spent six months in the training area learning discipline.

A thorough knowledge of how and when to salute is of primary importance to all military men.

Salute with the Hand:

(Par. 58, I. D. R., (1), *Hand*, (2), Salute). Raise the right hand smartly till the tip of the forefinger touches the lower part of the headdress or forehead above the right eye, thumb, and fingers extended and joined, palm to the left, forearm inclined at about 45 degrees, hand and wrist straight; at the same time look toward the person saluted. Drop the arm smartly by the side.

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Don't Salute:

1. With hat on back of head.
2. With cigar or cigarette or pipe in mouth.
3. With one hand in pocket.
4. Standing on one leg, with heels apart or otherwise slouching.
5. In a listless, sloppy, or half-hearted way.
6. Not looking at person saluted or with eyes on ground and head down.
7. With coat or shirt unbuttoned.
8. In a clumsy or apologetic way.
9. With cigarette or cigar in right hand.
10. With palm of hand turned toward face.
11. With elbow too high or too low.
12. Lowering the head to meet the hand.
13. Improper conformation of hands and wrist.

Special Regulations Regarding Saluting:

1. Personal salutes will not be rendered inside stores, theaters, hotels, restaurants, churches, street cars, or railway coaches, unless the junior is addressed by or addresses a senior entitled to the salute.

Note—(Salutes will be rendered in railway depots and in front of all stores, hotels, etc.).

2. Unless otherwise prescribed by commanding officers, an officer or clerk at work at a desk will not cease work on the approach of a senior unless addressed by or unless he addresses a senior entitled to the salute. If standing, he will render the prescribed salute.

3. Salutes will **not be dispensed with because the junior saluting or the senior entitled to the salute is riding in an automobile, motorcycle, or other vehicle**—except that the driver of the motor or other vehicle will not salute when actually driving. Occupants of vehicles not in motion (except the drivers) will, if possible, alight before saluting the colors. When the National Anthem is played in a military post or camp, all vehicles will stop and military occupants (except drivers) will alight and render the prescribed salute. Occupants of vehicles will sit erect when rendering or returning salutes.

4. Reliefs of working parties resting, or not actually engaged in work, will render the prescribed salute.

5. Officers will not dispense with the salute, but will require it in every case where regulations prescribe it. After the salute has been rendered, if the situation makes it desirable, the officer may command "Carry on" or "Rest." The expression "Carry on" means "Continue with what you were doing."

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6. Army Field Clerks are not entitled to the salute from enlisted men.

7. Officers and men reporting to seniors indoors will salute, whether covered or uncovered.

8. An officer or an enlisted man mounted and riding at a gait faster than a walk will bring his horse to a walk before saluting, except when on duty requiring an increased gait.

9. In all cases not herein excepted the prescribed salute should be rendered. If special cases arise in which it is thought desirable to dispense with the salute, the salute should be rendered and special cases reported through channels to Headquarters for consideration.

Salutes:

1. **(Par. 376, A. R.)** In rendering personal honors, when the command presents arms, officers and men in uniform who are not in formation and are in view and within saluting distance shall salute and shall remain in the position of salute until the end of ruffles and flourishes, or, if none, until "order arms" (C. A. R. No. 50).

2. **(Par. 377, A. R.).** The national or regimental color or standard uncased, passing a guard or other armed body will be saluted, the field music sounding "To the Color" or "To the Standard." Officers and enlisted men passing the uncased colors will render honors as follows: If in uniform they will salute as required in sub-paragraph 1 or Par. 383, A. R; if in civilian dress and covered they will uncover, holding the headdress opposite the left shoulder with the right hand; if uncovered they will salute with the right hand salute. (C. A. R. No. 59, Aug. 10, 1917).

3. **(Par. 378, A. R.)** (Changed by C. A. R. No. 5, W. D., 1914, and No. 50, W. D., 1917). Whenever the national anthem is played at any place where persons belonging to the military service are present, all officers and enlisted men not in formation shall stand at attention facing toward the music (except at retreat, when they shall face toward the flag). If in uniform, **covered,** they shall salute at the first note of the anthem, retaining the position of salute until the last note of the anthem; if not in uniform and **covered** they shall uncover at the first note of the anthem, holding the headdress opposite the left shoulder and so remain until its close, except that in inclement weather the headdress may be held slightly raised.

The same rules apply when "To the Color" or "To the Standard" is sounded as when the national anthem is played.

When played by an army band the national anthem shall be played through without repetition of any part not required to be repeated to make it complete.

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The same marks of respect prescribed for observance during the playing of the national anthem of the United States shall be shown toward the national anthem of any other country when played upon official occasions (C. A. R. No. 59, August 10, 1917).

4. **(Par. 381, A. R.)** When making or receiving official reports or on meeting out of doors all officers will salute. Military courtesy requires the junior to salute first, but when the salute is introductory to a report made at a military ceremony or formation to the representative of a common superior—as for example, to the adjutant, officer of the day, etc.—the officer making the report, whatever his rank, will salute first; the officer to whom the report is made will acknowledge, by saluting, that he has received and understood the report. (C. A. R. No. 50).

5. **(Par. 382, A. R.)** Salutes shall be exchanged between officers and enlisted men not in a military formation, or at drill, work, games, or mess, on every occasion of their meeting, passing near, or being addressed, the officer junior in rank or the enlisted man saluting first.

6. When an officer enters a room where there are several enlisted men, the word "attention" is given by someone who perceives him, when all rise, uncover, and remain standing at attention until the officer leaves the room or directs otherwise. Enlisted men at meals stop eating and remain seated at attention.

7. An enlisted man, if seated, rises on the approach of an officer, **faces toward him, stands at attention,** and salutes. Standing, **he faces an officer** for the same purpose. If the parties remain in the same place or on the same ground, such compliments need not be repeated. Soldiers **actually at work** do not cease work to salute an officer unless addressed by him.

8. Before addressing an officer, an enlisted man makes the prescribed salute with the weapon with which he is armed, or, if unarmed, with the right hand. He also makes the same salute after receiving a reply (C. A. R. No. 50).

9. **(Par. 383, A. R.)** In uniform covered or uncovered, but not in formation, officers and enlisted men salute military persons as follows: With arms in hand, the salute prescribed for that arm (sentinels on guard duty indoors excepted); without arms, the right-hand salute.

In civilian dress covered or uncovered, officers and enlisted men salute military persons with the right-hand salute.

Officers and enlisted men will render the prescribed salutes in a military manner, the officer junior in rank or the enlisted man salut-

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ing first. When several officers in company are saluted, all entitled to the salute shall return it.

Except in the field under campaign or simulated campaign condition a mounted officer (or soldier) **dismounts** before addressing a superior officer not mounted.

A man in formation shall not salute when directly addressed but shall come to attention if at rest or at ease (C. A. R. No. 50).

10. **(Par. 384, A. R.)** Saluting distance is that within which recognition is easy. In general it does not exceed thirty paces.

When an officer entitled to the salute passes in rear of a body of troops, it is brought to attention **while he is opposite the post of the commander.**

In public conveyances, such as railway trains and street cars and in public places, such as theaters, honors, and personal salutes may be omitted when palpably inappropriate or apt to disturb or annoy civilians present (C. A. R. Nos. 33 and 50).

11. **(Par. 392½ A. R.)** Soldiers at all times and in all situations pay the same compliments to officers of the Army, Navy, Marine Corps, and Volunteers, and to officers of the National Guard in uniform as to officers of their own regiment, corps, or arm of service. (C. A. R. No. 50).

12. **(Par. 392½, A. R.)** Officers and soldiers shall at all times pay same compliment to officers of allied or neutral countries.

13. If marching, the salute is executed when at six paces from the officer entitled to the salute; the carry is resumed when six paces beyond him.

14. The national color renders no salute.

As a rule, **juniors will give way to seniors and at all times juniors will show deference to their seniors and will not ignore their presence.** These rules will apply whether in vehicles, on horseback, or on foot. In accompanying officers, juniors will walk or ride on the left of their seniors, unless there be special reason to the contrary.

(Attention invited to Par. 406–434, A. R., inclusive.)

(Par. 437, A. R.) At every military post or station the flag will be hoisted at the sounding of the first note of reveille, or the first note of the march, if a march be played before the reveille. The flag will be lowered at the sounding of the last note of the retreat, and while the flag is being lowered the band will play the national anthem, or, if there be no band present, the field music will sound "To the Colors." When "To the Colors" is sounded by the field music while the flag is being lowered the same respect will be observed as when the national anthem is played by the band, and in either case officers and enlisted men out of ranks will face toward the flag,

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stand at attention, and render the prescribed salute. The national flag will be displayed at one seacoast or lake fort of a group of forts within sight of each other at the beginning of and during an action in which the forts may be engaged whether by day or by night. (C. A. R. No. 50.)

Flags

There are three kinds of flags, post, garrison, and storm, which are flown from the flagstaff of the post or camp. The flag is raised quickly and lowered slowly. No part of the flag should ever be allowed to touch the ground. Following an old naval custom when the flag is to be flown at half mast it is first raised to the masthead and then lowered to half mast. Our flag is composed of thirteen stripes. The upper and lower strips are red. The thirteen stripes stand for the thirteen original States. The field of blue in the upper left hand corner contains forty-eight stars representing the forty-eight States in the Union. Upon the admission of a new State a new star is added the following 4th of July.

The nation's flag belonging to a dismounted organization is called its colors while that of a mounted organization is its standard. A guidon is the flag of an individual mounted organization. For the artillery it is scarlet with crossed guns superimposed in gold. In the upper angle of the guns is placed the regimental number and below the battery letter. The cavalry guidon is red and white, the upper half red and the lower half white. In the upper half in white is the regimental number and in the lower half in red the troop letter.

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CHAPTER III

MATÉRIEL

PART I

Note: The numbers given in Part I, unless otherwise indicated, refer to pages in the Handbook of the 3-inch Gun Matériel.

The Limber Model of 1902

The principal parts of the limber are as follows: the wheels, axle, frame, ammunition chest, pole, doubtletree, singletrees, neck yoke (commonly called "pole yoke"). The axle is made of a single hollow piece of forged steel. Being hollow gives it more resiliency and permits its being used as a reservoir for oil, the side thrust of the carriage on the road causing it to slush out into the axle bearing and keep the wheel boxing properly lubricated. The frame consists of a middle rail and two side rails, the middle rail being a split tube, one half above and the other half beneath the axle. The front end of the middle rail acts as a clamp for the pole, the rear end houses the pintle bearing. For description of the ammunition chest see page 92. All poles are now made of steel, the new type supplanting the old wooden model. The doubletree "strap" is of steel, the neck yoke an accessory of the limber, and the mogul springs are a part of the harness. Three canvas buckets are carried under the seat, ***bottom up*** to insure quick drying. They should be folded as follows: Grasping the top ring in one hand, the bottom ring in the other, rotate each in opposite directions until the bucket is folded compactly. The limber prop is an integral part of the limber, secured to the bottom of the pole clamp. When not in use, it is raised to a horizontal position beneath the foot rest. The pole prop is scissors-shaped and is placed under the end of the pole when additional support is needed.

The following tools and equipment are carried on each limber: (a) Pick—carried on the footboard, secured by two straps with the head on the left of the limber, the two points in steel holders or

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brackets, one on the footboard and the other riveted to the under side of the chest; (b) Axe—underneath chest on left side, inserted from the rear, handle to the front, the cutting edge toward the left wheel, the strap around the handle near the head holding it securely; (c) Hatchet—on the left side of the chest, head to the front, secured by strap; (d) Short-handled shovel—under the limber, on the right, inserted under the footboard, handle to the front, and between the chest and the axle, point down. A strap near the end of the handle holds it in its bracket; (e) Pole prop—under the chest, in the rear, parallel to the axle, with strap under the left side; (f) Picket rope—(one for light batteries, two for horse) folded end to end in three operations, secured to the front of the chest by means of four "picket rope straps"; (g) Lantern—in a bracket riveted to the front of the chest resting upon a bracket pad consisting of a soft piece of copper, to which are riveted several layers of canvas which reduce shock and globe breakage. A split strap, fitted over the lantern head, secures it in the bracket; (h) One paulin—on caisson limbers, two on gun limbers; (i) three canvas watering buckets (see above).

The Caisson Model of 1902

The principal parts of the caisson are as follows: the wheels, axle, frame, road brakes, and ammunition chest. The axle is similar in design but larger in cross section than the limber axle, and lugs for the attachment of the chest and apron are located differently. The frame is diamond-shaped and consists of two steel rails of channel section riveted to the lugs on the axle, meeting in front at the lunette, and in the rear at the pintle (for a detailed description of the frame, see page 97). The middle rail is formed of two steel angles riveted under the axle, the front ends meeting the side rails at the brake channel and the other ends meeting the side rails at the pintle bearings. The front end of the side rails, the frame reinforce-plate, and the lunette bracket are securely riveted together. The cross brace of channel steel is riveted to the side rails at the point where the limber wheels touch in turning. The pintle bearings and the pintle are similar to and interchangeable with those of the limber.

Moving the brake lever in the direction indicated above rotates the brake shaft in a counterclockwise direction, the brake crank (9) moving forward at the same time and pressing the spring cover end (8) against the brake spring (2). The force is transmitted through the spring (2) to the shoulder (3) on the brake rod (5) which moves forward carrying the inner part of the brake beam to the front. As

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the brake beam is pivoted near the center (4), the brake shoes move to the rear against the wheel. (See pages 77 and 97, 3-inch Handbook.)

The following tools are carried on each caisson: (a) Axe—held in a bracket on the front of the chest above the foot rest, head to the

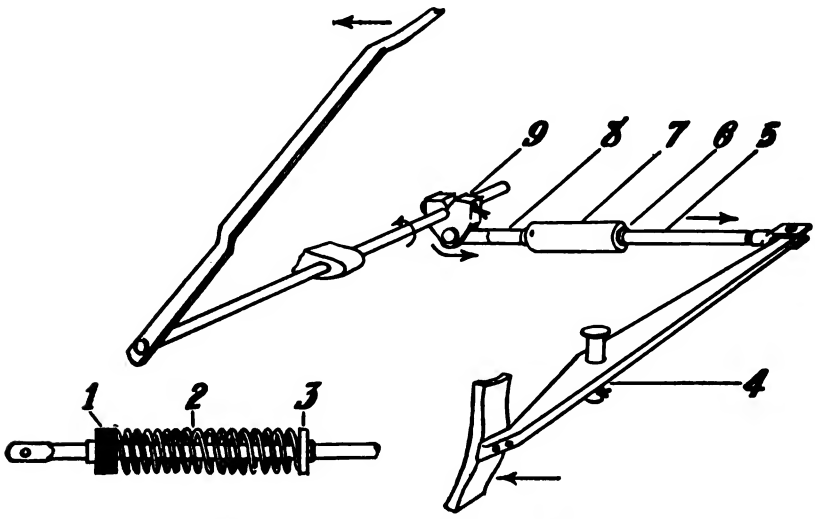

FIGURE 1. THE 1902 ROAD BRAKE

1. Brake Spring Cover End.
2. Brake Rod Spring.
3. Shoulder.
4. Fulcrum Pin.
5. Brake Rod.
6. Brake Spring Cover Head.
7. Brake Spring Cover.
8. Brake Spring Cover End.
9. Brake Crank.

left, cutting edge down, with a strap attached near the center of the handle; (b) Long-handled shovel—point up in a bracket riveted to the bottom of the chest over the axle. The end of the handle is in a curved bracket attached to the cross brace; (c) Pick mattock—secured under chest, the handle resting in a loop over the axle, head on the brake channel; (d) Spanner—on the left side of the chest below the door stop bar slot, held by a strap; (e) Wrench ($\frac{3}{4}$x$\frac{5}{8}$ inch)—is on the left of the chest, above the door stop bar slot, held by a strap.

3-Inch Gun Carriage Model of 1902

Cover nomenclature of all parts as shown in Plate X, page 67. Study pages 60, 67, 68, 71, 72, 73, 75, and 78, 3-inch Handbook.

The carriage for the 3-inch gun is known as a long-recoil type (45 inches) allowing the gun sufficient length of recoil upon the carriage to render the latter stationary under firing stresses. The carriage is divided into three parts as follows: the lower carriage

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consisting of the trail, lunette, elevating device, wheels, and axle, the intermediate carriage consisting of the rocker and traversing device; the upper carriage consisting of the cradle, firing mechanism, and shields.

Study pages 71–72 for detailed description of the trail. When the carriage is limbered the downward pressure of the lunette against the pintle is 115 pounds.

Armor

All shields were originally 0.2 inch thick, but now are 0.15 inch thick. All are tested at 100 yards for penetration by rifle bullet.

1902 Gun Carriage	Apron	Hinged under the axle, reaches to within 5 inches of the ground; 2 latches.
	Main Shield	Attached to axle at 6 points; braced against shield brace; hood over gun port; peep sight port with shutter; extends from axle to 4 inches below tops of wheels.
	Top Shield	Hinged to main shield; panoramic sight port with shutter, 2 fastenings; upper edge 62 inches from ground.
1902 Caisson	Apron	5.5 inches from ground; convex to the front.
	Chest Door	Swings through arc of 120°; 2 props.
	Chest Front Plate	Same quality as other shields.
1916 Caisson	Apron	4.5 inches from the ground.
	Chest Back	Same as carriage shields.
	Chest Door	Same as carriage shields.

Four ammunition carriers, closed by a hinged cover in the rear, resting on the axle, carry emergency rounds of shrapnel. They are joined in front, forming a foot rest and a support for the road brake. This brake is the same as illustrated above except that the brake lever is double handled and engages on a double ratchet brake segment.

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The Limber Model of 1916

Study pages 103–106. Many parts of the 1916 model limber and caisson are the same as the model of 1902. Cover nomenclature of all new parts shown in Plate XVII, page 103, 3-inch Handbook.

Like the 3-inch gun limber, model of 1902, the 1916 limber is metal throughout except the felloes and spokes of the wheels. The main differences are in construction. The bucket seats instead of being three distinct seats are made into one, the flat top extending the length of the chest and two small steel plates being riveted in place to form the bucket compartments. The top of the seat extends the full length of the chest and its height is greater than that of the 1902 limber. Two lock bars fasten the chest door, there being no right and left shot bolts as on the 1902 limber. The chest door handle is riveted to the chest on the right of the pintle bearing. The axe is carried on the right of the chest, the pole prop on the footboard, secured by a center strap. The frame consists of a middle and two side rails, the former being identical with the middle rail of the 1902 limber, except that the pintle bearing bracket is square instead of round. The chest is riveted to the side rails. The limber also carries an automatic pole support. Both model limbers carry four (4) long straps on the upper part of the chest for blanket rolls. In attaching them care should be taken to secure the long straps to the steel loops next to the bucket seats.

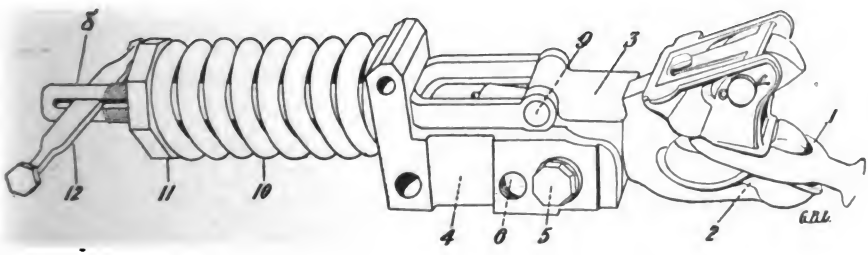

FIGURE 2. THE AUTOMATIC POLE SUPPORT

1. Lunette.
2. Pintle (with projecting lug).
3. Pintle Bearing.
4. Pintle Bearing Guide.
5. Trunnion Bolt.
6. Pintle Bearing Bolt.
8. Spring Rod.
9. Spring Rod Pin.
10. Pole Supporting Spring.
11. Spring Rod Nut.
12. Guide Bolt.

Study page 104 and Plate XVIII. The purpose of the automatic pole support is twofold: (a) to maintain the pole in a horizontal position and (b) to take up as much of the shock of starting as possible. (a) The pintle (2) passes through the bronze pintle bearing (3) which is fastened to the steel pintle bearing guide (4)

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by two trunnion bolts (5), one on each side of the guide. To the top of the pintle bearing (3) is pinned the spring rod (8) about which the pole supporting spring (10) is assembled, the spring being compressed between the pintle bearing guide and the spring rod nut (11). A guide bolt (12) secured to the middle rail passes through the end of the spring rod, preventing vertical rotation of the rod. When the pole is dropped, the pintle tends to rise. The lunette bears down upon the pintle and its lug, causing the pintle Bearing to rotate on the two trunnion bolts. This movement draws the spring rod to the rear compressing the spring against the pintle bearing guide from which the force is transmitted to the middle rail. Since the pole is connected directly to the middle rail and as both tend to revolve about the axle as a center, pressure such as the spring exerts against the elevated part of the middle rail will cause the pole to rise to a horizontal position. (b) The pole support takes up starting strain as follows: a small pintle bearing spring (see Plate XVIII) lies between a nut on the end of the pintle and the pintle bearing, which is gradually compressed when the carriage starts, thereby relieving the shock. The lug on the end of the pintle is to prevent vertical rotation of the lunette.

The Caisson Model of 1916

Cover nomenclature of all new parts shown in Plate XIX, page 108, 3-inch Handbook. Study pages 107–115.

The main differences between the 1902 and the 1916 model caisson follow: the middle rail is made of two pieces of steel channel section, connected by the middle top plate. A pintle seat is formed at the rear of the middle rail and a lunette bracket is riveted to the front. Two side rails of cast steel extend the length of the chest. (Study carefully second paragraph, page 110.) The apron instead of swinging to the rear in its traveling position is swung to the front and secured to the footboard. The fuse setter bracket is secured to the front side of the axle on the left of the trail. The caisson chest door is hinged to the upper side of the chest on the front side. The brake is of the band type and is similar to that on the 1916 gun carriage, parts being interchangeable except levers. (For a detailed description of the 1916 band brake, see Plate XXI, and pages 112–113.) Tools are carried as described on page 115.

The Wheel

Study the description of the wheel, pages 77–78, 3-inch Handbook. The principal parts of the 3-inch wheel are: felloe, spoke,

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hub, hub cap, tire, tire bolts, hub liner, hub ring, hub band, oiling device, dust cap. There are two types of wheel fasteners:

The outside wheel fastening.—The front and rear sides of the axle have tapered slots at the end of the spindle. A bronze U-shaped device fits into these slots with a plunger engaging on the shoulder beneath the spindle and holding the wheel fastening in place. A bronze hub cap with a latch and spring screws over the wheel fastening. A hub ring is riveted to the hub of the wheel, with holes bored at regular intervals, permitting the plunger to engage and hold the hub cap in place.

The inside wheel fastening.—The wheels are held in place by a bronze wheel fastener (hinge type), which is held together on one side by a flat-headed steel pin, and the other side by a wheel fastener hasp and large split pin. The wheel fastener (on its flange which projects into a recess in the wheel boxing) has four locking lugs, which engage with four steel lugs of the same shape, in the wheel. In putting on a wheel the wheel fastener is held stationary while the wheel is slipped into place so that the lugs of the wheel and the wheel fastener clear each other, the wheel is turned one quarter revolution so that the lugs engage, the wheel-fastening hasp is pushed down over the outer surface of the wheel boxing and the stud, after which the wheel-fastening hasp split pin is inserted and ends spread to prevent loosening. The wheel-fastening body has a shoulder which fits into a groove in the axle, which, when placed in the groove and the hasp attached, cannot fall loose. It is at this point that the main shock is felt. This apparatus alone is responsible for keeping the wheel in place.

The Rocker

The rocker is the intermediate part between the upper carriage or cradle, and the lower carriage, or trail (1). The main parts of the trail are the flasks. It forms a platform upon which the cradle is moved in azimuth, and moves with the cradle relatively to the other parts of the carriage in elevation. It is built up of an angle (2) formed to shape, to which three steel forgings—the pintle socket (3), the traversing gear case (4), and the traversing plate (5)—are riveted. To the left angle iron is riveted a bronze azimuth scale (6) with a maximum registration of 140 mils. Its front end is supported by that portion of the axle between the flasks (1-A). It is assembled by inserting the axle through two bronze bushed holes in the pintle socket when the trail (1) is assembled on the axle (7). The upper portion of the pintle socket (3) is formed into a bronze lined socket and bearing surface

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for the cradle pintle and is provided with two clips (8) to take the corresponding parts of the latter. The rear end of the rocker terminates in the traversing plate (5), bronze lined to form a bearing for the cradle rear clip. The lower side of the traversing plate (5) is

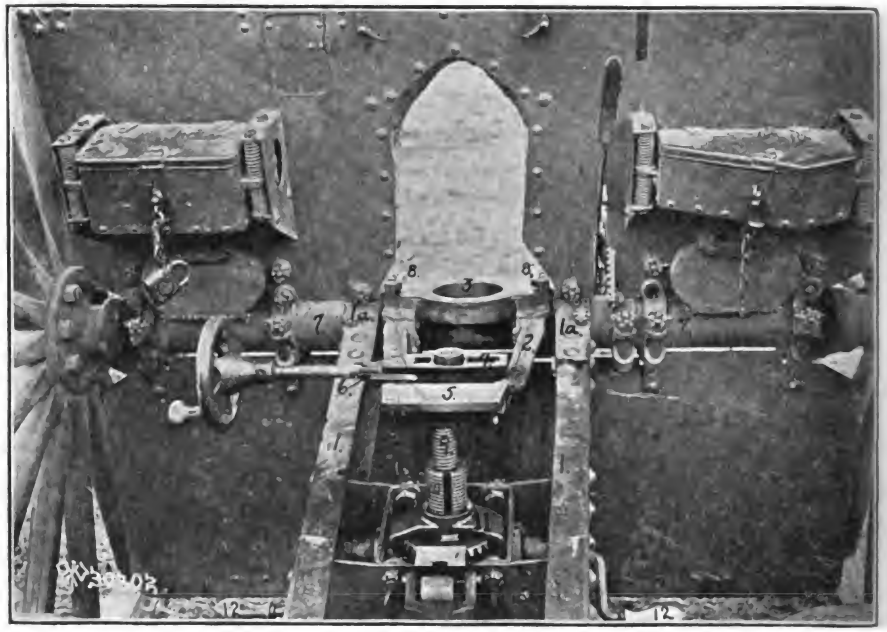

FIGURE 3. THE ROCKER

1.	Trail.	5.	Traversing Plate.	9.	Inner Elevating Screw.
2.	Rocker.	6.	Azimuth Scale.	10.	Outer Elevating Screw.
3.	Pintle Socket.	7.	Axle.	11.	Elevating Gear Bracket.
4.	Traversing Gear Case.	8.	Pintle Socket Clips.	12.	Elevating Crank.

finished to take the head of the inner elevating screw (9) to which it is secured by the elevating pin. The traversing gear case (4) which forms a housing for the traversing mechanism is riveted to the rocker angle (2) in front of the traversing plate (5).

The Cradle

The main parts of the cradle to be covered in the nomenclature are: cradle body (1), cradle head front, cradle head rear (2), pintle (3), traversing lug (4), rear clip (5), elevating and traversing lock lug (6), shoulder guard (7), recoil indicator guide (8), front sight bracket support (9), rear sight bracket support (10), quadrant fastening (11). The following parts are also shown firing handle (12), firing shaft (13), retaining ring bolts (14). Study pages 67 to 70, 3-inch Handbook.

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The cradle has a threefold function: (a) It receives the gun, (b) guides it in recoil, and (c) forms a housing for the recoil-controlling parts. The following points will be found in the Matériel Handbook: what the cradle is made of, names of the four steel forgings

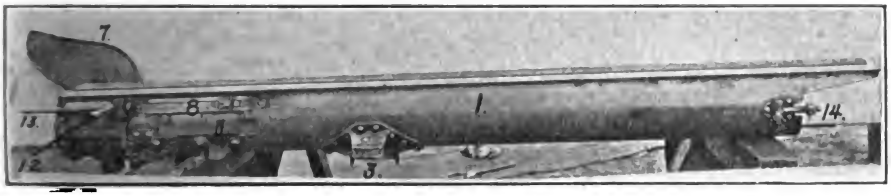

FIGURE 4. THE CRADLE (right side)

riveted to the bottom of the cradle, how the cradle is disengaged for dismounting, the purpose of the felt washer in the cradle head rear, the shape of the cradle head front and the retaining ring, the shape

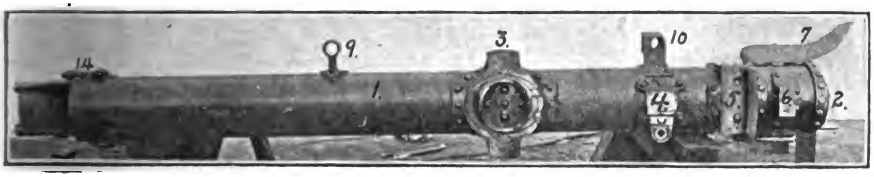

FIGURE 5. THE CRADLE (form beneath)

of the cradle itself, the purpose of the flanges, what the cradle pintle is, the function of the two bronze spring support guides, all parts riveted to the right and left sides of the cradle, what the cradle contains.

The Recoil Mechanism

The recoil-controlling parts of the carriage include the cylinder (1), piston (2), counter-recoil buffer (3) and counter-recoil springs (4).

The following points should be emphasized: the cylinder (1) lies inside the cradle and is surrounded by the counter-recoil springs (4), it is closed in the rear by the cylinder end, from which the cylinder end stud (16) projects and to which the recoil lug is attached by the cylinder end stud nut (13). Inside the cylinder (1) are three throttling bars, set 120° apart. These bars are uniform in width but vary in height, are equal at both ends, dropping off very rapidly at the rear of the cylinder and then rising gradually as they approach the front. Within the cylinder (1) lies the piston and piston rod (2), which is attached to the cradle head front (5) by the

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piston rod nut (11) and is held stationary while the gun recoils. The piston rod (2) is hollow and into the rear is fitted very closely the counter-recoil buffer (3), a tapered bronze rod attached to the cylinder end. The cylinder contains hydrolene oil.

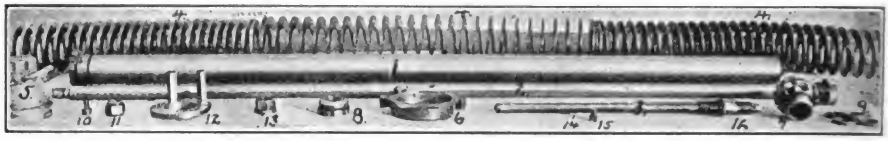

FIGURE 6. THE RECOIL MECHANISM

1. Cylinder.
2. Piston.
3. Counter-Recoil Buffer.
4. Counter-Recoil Springs.
5. Cradle Head Front.
6. Retaining Ring.
7. Cylinder Head.
8. Gland.
9. Packing Rings.
10. Filling Plug.
11. Piston Rod Nut.
12. Spring Support.
13. Cylinder End Stud Nut.
14. Screw for Cylinder End Stud.
15. Drain Plug.
16. Cylinder End Stud.

Study pages 68–70 and Plate XI, 3-inch Handbook.

There are two types of counter-recoil springs—the flat type (1), and the square steel bar type, outer (2a) and inner (2b). Whenever any of the new outer and inner springs are used, two bronze separators (3) are assembled between the spring sections. The springs are assembled under initial pressure of 750 pounds.

Action of Mechanism During Recoil

The pressure of the expanding gases in the tube against the breech drives the gun to the rear about forty-five inches, carrying with it the cylinder and compressing the springs. The piston rod is attached to the cradle head front and remains stationary. The oil in the cylinder first lies in front of the piston head, but as the cylinder

FIGURE 7. COUNTER-RECOIL SPRINGS

1. Flat Counter-Recoil Springs.
2a. Outer Counter-Recoil Springs.
2b. Inner Counter-Recoil Springs.
3. Spring Separator.
4. Dust Guard.
5. Cradle Brush.

moves to the rear it is forced through the three small slots between the piston head and the throttling bars to the opposite side of the piston head. The hydraulic braking effect thus set up is proportional to the size of the openings and the rate of movement to the rear. During the first few inches of recoil the openings are large, as the throttling bars decrease rapidly in height, but from that

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point on they increase steadily in height causing the openings to become smaller and smaller until the energy of recoil is totally absorbed. The piece is now in "Recoil," springs compressed, oil in rear of piston head, the buffer recess in the piston rod filled with oil. The counter-recoil springs being compressed force the cylinder to the front, carrying the gun with it. The openings between the piston head slots and the throttling bars become larger and the resistance to the passage of oil from rear to front of the piston head becomes less. At a certain point in counter-recoil, the tapered counter-recoil buffer enters its recess, displacing the oil therein, the hydraulic braking effect thus created causing the gun to return into battery without jar. (To be used in connection with Plate XI, 3-inch Handbook.)

Straps and their Uses

Study pages 92, 93, 106, and 114, 3-inch Handbook. In order to be complete all carriages must have full complement of straps for tools and equipment. Each limber is provided with four picket rope straps for the purpose of securing picket rope to the chest. There is a split strap for the lantern. Three long straps are provided for the paulin. Attached to the same buckles are three grip straps that hang in front of the chest. These straps are for cannoneers. Behind the bucket seats and folded neatly are four blanket roll straps. They are very long and are attached to the steel loop next to the bucket seat, so that when the blanket rolls are placed on the carriages they can be buckled conveniently. The pick is held to the footboard by means of two straps, one attached to a loop on the right of the lantern bracket on the footboard, the other over the head on the left of the footboard. On limbers, model of 1902, the pole prop is carried under the limber chest in rear of and parallel to the axle, with a strap which fits over the left end of the pole prop. The axe is held in place by a strap near its head, which is fastened under the chest to the left of the pintle. The short-handled shovel has a strap attached to the handle bracket under the footboard of the limber. The hatchet is carried on the left of the chest with a short strap around the handle near the head of the hatchet. These straps are on all gun limbers, model of 1902. The caisson has three paulin straps exactly the same as those carried on the limber. On the front of the chest is a short strap for securing the axe; two on the left of the chest for holding the $\frac{3}{4}$x$\frac{5}{8}$ inch wrench, and the spanner. A short strap attached to the cross-piece on the trail holds the handle of the long-handled shovel in place. A large strap with reinforced

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part secures the pick mattock to the brake channel on the right under the caisson chest. Three grip straps are attached to the same loops as the paulin straps.

Tools and their Uses

For the list of tools carried in canvas tool kits in the trail of each piece, see page 189, 3-inch Handbook. In addition to tools in this

FIGURE 8. A TYPICAL TOOL KIT

1. Tubular Oil Can.
2. Spring Compressor.
3. Wrench for Assembling Recoil Springs and Grindstones.
4. Spring Centering Tool.
5. Bronze Drift (large).
6. Bronze Drift (small).
7. Horizontal Oiler.
8. Cylinder Head and Gland Wrench.
9. Caisson Wrench.
10. Hammer. Cross-peen.
11. Pliers. Wire-cutting.
12. Cold Chisel.
13. Filling and Drain Plug Wrench.
14. Screw Driver.
15. Bronze Drift (large).
16. Wrench (¾ x ⅝ inch).
17. Wrench (¾ x 1 inch).
18. 8-inch File.

canvas kit, equipment carried in the trail box consists of the following: 1 hand fuse setter, with case; 2 lanyards; 1 leather pouch for spare parts; 1 lock washer holder; 1 oil can and horizontal oiler; 1 spool of copper wire No. 20, 3 lbs.

The tools and equipment found in the trail box are sufficient for all work a gunner will ordinarily be required to do in taking care of the carriages of his section. Never use a screw driver as a chisel. The screw driver is issued for work around the gun, oil holes, screw covers, screws that may be too tight or too loose, and can be used for spreading ends of small split pins. It is also handy in pressing strands of wire into the proper place when wiring cylinder head and gland. Never use a chisel or steel punch when a bronze drift should be used. The files are not issued for cutting rust from bearing surfaces about gun or other carriages. The main use found for files

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will be in smoothing sharp points on tires and sharpening chisels. The hammer should never be used against the metal surfaces but always use a bronze drift or a piece of wood. The pliers are issued for cutting wire, and pulling out split pins, not for a hammer. The filling and drain plug wrench is issued for removing and replacing these plugs, and for the nuts on the retaining ring bolts. When removing nuts from bolts elsewhere on the gun, use ¾ x ⅝-inch wrench found in tool kit, or the large ¾ x 1-inch.

The Gun

The gun is of the "built up" type, is made of nickel steel, and consists of the tube, jacket, locking hoop, and front clip. The jacket is shrunk upon the tube, causing a contractive pressure which opposes the expansive force of the gases in the tube and makes a safer and lighter gun. The rifling has a right hand twist which makes slightly less than one turn within the tube. Study in Plate I, how the locking hoop is attached to the jacket. The 1905 model is approximately fifty pounds lighter than the models of 1902 and 1904 and has smaller outside diameters, lower clip or hoop extensions, a different twist, and a breech recess with four threaded sectors instead of two. (See pages 13–14.) Study pages 72–74, Plate XII, 3-inch Handbook, and Figure 3 (this chapter).

The Elevating Device

The elevating device is of the Chinese or telescopic screw type and is housed between the flasks of the trail (1) just in front of the trail boxes. It gives large vertical movement in small space with little effort. The elevating bracket (11) is suspended between two cross transoms and is movable to prevent the screw threads from binding. The elevating cranks (12) extend through the flasks (1) and the projecting arms of the bracket (11), which form a bearing for them. To the end of each elevating shaft is fitted a pinion which meshes with a large bronze bevel gear provided with two inner keys. Two longitudinal keyways are cut in the body of the screw (10) and in these keyways, the keys of the bevel gear fit. The inner part of the outer screw is threaded to admit the inner screw (9). The inner screw is held stationary by the elevating pin, the outer screw revolving about the inner.

The action is as follows: pressure applied to the elevating crank handle rotates the crank (12) and its attached pinion. The vertical motion of the pinion is turned through an angle of 90° by the teeth on the bevel gear which revolves in a horizontal plane. The two

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keys on the bevel gear grip the outer elevating screw (10) like two fingers and cause it to rotate. The outer threads of the outer screw (10) engage with threads on the elevating gear bracket (11) giving the screw vertical motion. The inside of the bevel gear is not threaded. The two keyways on the outer screw (10) allow the screw to move vertically without binding against the keys. The rotation of the outer screw (10) moves the inner screw (9) which in turn elevates or depresses the rocker (12) and the gun.

The Traversing Mechanism

Study page 74 and Plate XIII, 3-inch Handbook.

The traversing device is housed in the traversing gear case (4, Fig. 3), the rocker angle (2, Fig. 3), and consists of a shaft called

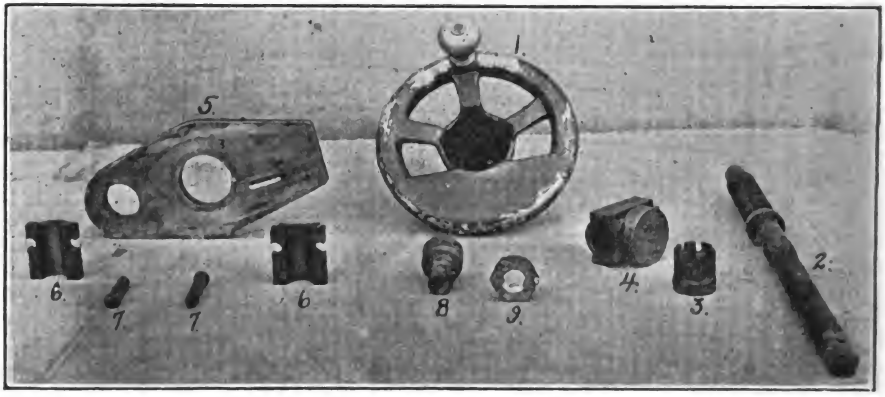

FIGURE 9. THE TRAVERSING MECHANISM

1. Traversing Handwheel.
2. Traversing Shaft.
3. Traversing Shaft Adjusting Nut.
4. Traversing Nut.
5. Traversing Link.
6. Traversing Shaft Bearing (split).
7. Taper Pins (secure bearing).
8. Traversing Link Pivot.
9. Traversing Link Pivot Nut.

the "traversing shaft" (2) with a threaded section (left hand thread) mounted upon a bearing (6) in the traversing gear case. The threaded section engages with a traversing nut with a cylindrical head (4) which moves longitudinally on the traversing shaft. The cylindrical head of the traversing nut fits into the bronze traversing link (5) which is secured to the traversing lug (on the cradle) by means of a traversing link pivot (8) and nut (9). A handwheel, called the traversing handwheel (1) is attached to the left end of the shaft (2) when mounted. An adjusting nut (3) is threaded to the shaft to take up lost motion.

The parts function as follows: turning the handwheel (1) rotates the traversing shaft (2) in its bearing, causing the traversing nut

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(4) to move along the threaded portion of the shaft. As the link (5) is attached to both the traversing nut and the cradle, any lateral movement of the nut is transmitted through the link to the cradle, causing the piece to be moved in azimuth. Instructors should bring out the following points: the traversing nut moves in a straight line from right to left along the traversing shaft, while the cradle moves on the arc of a circle, being pivoted upon the axle. The cylindrical head formed on the upper surface of the traversing nut is connected to the traversing lug by the traversing link. This traversing link moves freely about both the traversing nut and the traversing link pivot, by which it is attached to the traversing lug, in a direction at right angles to the traversing shaft. This movement compensates for the radial movement of the cradle around the pintle and permits traverse.

To Dismount the Traversing Mechanism

Tools required: 1 hammer; 1 steel punch; 1 pliers; 1 screw slot wrench and 1 wrench ¾ x ⅝ inch. Traverse cradle (breech end) to the right until traversing link pivot is clear of the traversing gear case. Remove traversing link pivot split pin, and insert round shoulder of screw slot wrench in the head of the traversing link to prevent it from turning. Then with ¾ x ⅝ inch wrench loosen the traversing link pivot nut allowing the link pivot to drop, in order that shoulder of link pivot nut will not foul on the cradle jaw. The cradle is now clear of the traversing device. Next remove the split pin holding the traversing handwheel to the traversing shaft. Remove the handwheel. With the steel punch and hammer, drive out the bearing pins on the left of the traversing link. Remove the traversing link. Pull out the traversing shaft. The traversing shaft split bearing and traversing nut will come out with the shaft. See page 82, 3-inch Handbook.

To Mount the Traversing Mechanism

After cleaning and lubricating all parts replace the traversing nut on the traversing shaft; assemble split bearing with flat surface up and slide into its seat. Put in bearing taper pins and attach the hand wheel. Rotate shaft, running the traversing nut to the extreme right side of the traversing gear case. Slip on the traversing link, keeping the rounded end to the right. Push the cradle over until the traversing lug on the cradle is in line with the hole in the rounded end of the traversing link. Insert the traversing link pivot from beneath. Screw on the traversing link pivot nut.

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To Dismount the Elevating Mechanism

Tools required: 1 cross-peen hammer; 1 steel punch; 1 pair pliers. With the pliers remove the split pin in the end of the elevating pin. Remove the elevating pin, being careful not to let the muzzle of the gun drop (have a box or some convenient object for it to rest upon). Remove the inner elevating screw, unscrewing by hand. Then remove the elevating screw cover which is secured underneath the bracket. Center the bracket so that the bevel gear will not strike against the bolt heads on the transom. Take out outer elevating screw by operating the crank handle. This screw passes out through the bottom. After disengaging from the keys on the bevel gear, the operation of removing the outer elevating screw is done by hand, screwing to the left. Raise the trail, placing the end of it on a box and with a hammer and steel punch remove the steel taper pins holding the bevel pinions to the crank shaft. This must be done from under the trail. Pull out the crank shafts being careful to hold the bevel pinions while doing so, to prevent their dropping and injuring the teeth. Tip the top of the elevating gear bracket toward the axle and pull out the bevel gear, which is a large circular bronze wheel. See page 82, 3-inch Handbook.

If it is desired to dismount the bracket, remove the split pins from the transom bolts, and with a ¾ x ⅝ inch wrench remove the nuts and bolts. Pry the elevating gear transoms that form the bearings for the elevating gear bracket aside, and lift out the bracket. See page 83, 3-inch Handbook.

To Mount the Elevating Mechanism

Replace the bracket. Push the cross transoms back into place after seeing that the bearings are clean, and replace the bolts and nuts. Tip the bracket toward the axle, replacing the bevel gear. Next the crank handle is put in, holding the bevel pinion engaged in the teeth of the bevel gear, so that the key on the crank shaft will slide in the keyway in the bevel pinion. Be sure to have the large ends of the holes in the bevel pinion and crank shaft in line, otherwise the taper pins will not fit properly. Replace the outer elevating screw from beneath, screwing it by hand. After reaching the point where it engages with the bevel gear, the screw must be rotated by hand, and at the same time the bevel gear is turned by the elevating handles, in order that the keys of the bevel gear may engage in the longitudinal keyways cut in the outer elevating screw. Complete the operation with the elevating crank handles. Bring the elevating screw up until it is just flush with the top of the

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bracket. Screw in the inner elevating screw by hand until about a quarter turn remains before the shoulder rests on the outer screw. Then holding the cross head of the inner screw stationary, operate the mechanism causing the screw to rise. Engage it in a seat under the end of the rocker. Replace the elevating pin and split pin, spreading the ends.

The Breech Mechanism

Study the very detailed description of the breech mechanism on pages 23–28 and Plate III, 3-inch Handbook.

The firing lock case (10) contains the following: trigger shaft (12), trigger shaft detent (13), trigger fork (11), firing pin

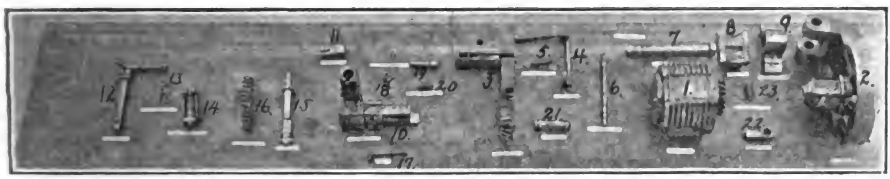

FIGURE 10. THE BREECH MECHANISM

1. Breech Block.
2. Block Carrier.
3. Operating Lever.
4. Lever Latch.
5. Lever Latch Spring.
6. Lever Latch Pivot.
7. Hinge Pin.
8. Extractor.
9. Extractor Lever.
10. Firing Lock Case.
11. Trigger Fork.
12. Trigger Shaft.
13. Trigger Shaft Detent.
14. Firing Spring Sleeve.
15. Firing Pin.
16. Firing Spring.
17. Sear.
18. Locking Bolt Nut.
19. Locking Bolt.
20. Locking Bolt Spring.
21. Lever Pivot.
22. Block Latch.
23. Block Latch Spring.

(15), firing spring (16), firing spring sleeve (14), and sear (17). A locking bolt (19) with nut (18), pin and spring (20) in the lower end of the firing lock case, fits in a recess bored in the carrier face and holds the firing lock case in position.

The breech mechanism, as described above, is rightfully termed "FOOL-PROOF." The gun cannot be fired until the block is latched because the block is mounted concentrically in relation to the carrier hub, and eccentrically in relation to the bore. When the breech is opened, the lever rotates the firing pin vent in the end of the block away from the firing pin about one quarter of an inch, thereby completely masking the firing pin.

The Firing Mechanism

The firing mechanism is of the continuous pull type. The firing pin strikes and returns to the normal automatically as often as the firing handle is pressed or the lanyard pulled. Study pages 24–26, 3-inch Handbook carefully. Explanation of Figure 11: first stage—

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spring is compressed between the shoulder of the firing pin (P) and the end of the sleeve (S). Second stage—pressure applied to the trigger shaft has rotated the trigger fork (F) in a clockwise direction, thereby raising the sleeve (S) compressing the spring and gradually forcing

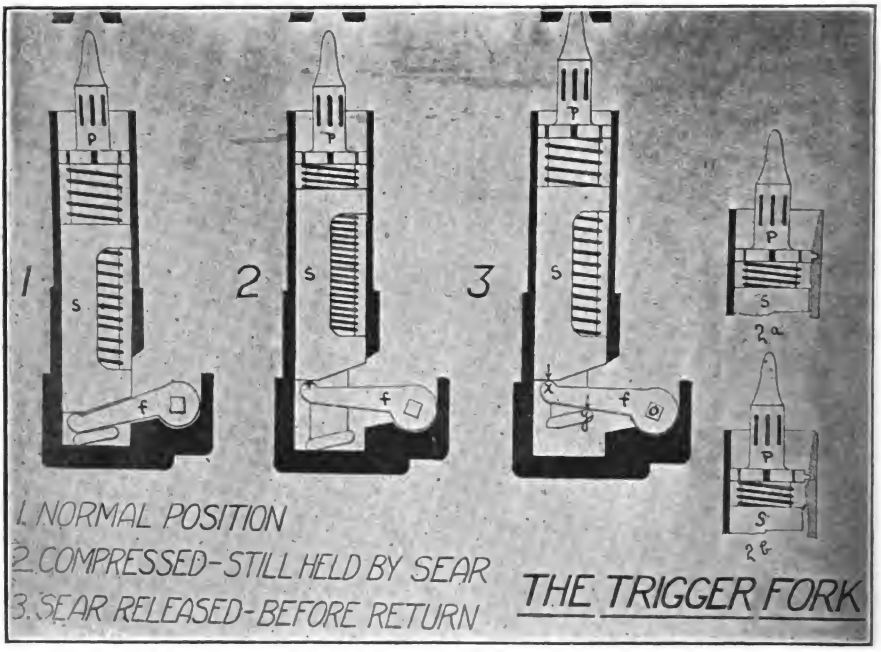

FIGURE 11. THE FIRING MECHANISM

the sear outward (see 2 a and 2 b), which show sleeve (S) forcing sear to the right away from the collar on the firing pin (P). Third stage—the sear has been released and the firing pin (P) has descended. The spring is compressed against the collar on the firing pin (P) and the rear of the sleeve (S) pushing the sleeve (S) down, and the firing pin (P) up until it strikes the fork (F). But the distance OX is greater than OY and the downward pressure applied at X overcomes the upward pressure. The pin (P) is forced back into normal position as shown in stage 1.

To Dismantle the Breech Mechanism

Open the block. Remove the carrier hinge pin. The block is now free. Take out the extractor lever. Remove the extractor. Grasp the locking bolt nut, pulling away from the block until the bolt

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is clear of its seat. Swing the firing lock case upward and to the left until it disengages. Remove the firing lock case. Compress the two points of the trigger shaft detent removing the trigger shaft. Then pull the free end of the sear clear of the front shoulder of the firing pin, pulling out the firing pin until the trigger fork protrudes from its socket. Remove the trigger fork. The firing pin with its sleeve and spring can now be removed from its seat. Remove the sear from its seat. With the trigger fork pressed against the flat arm seat between the shoulder of the firing pin and the sleeve a lever motion compresses the spring and disengages the sleeve from the retaining shoulder allowing the sleeve to be removed. The firing spring screws off the firing pin. The operating lever can be removed from the carrier by pushing the pivot key from its seat. Next with the thumb holding down the block latch, rotate the block to the right, lifting it from the hub. Care should be taken not to drop any part of the breech mechanism.

Caution

"No. 1" should not handle the mechanism in a rough manner because the teeth of the operating lever are easily broken off. In opening the block it should never be swung to the full open position with a slam. Enough pressure should be exerted in order to move the cartridge clear of the breech. In actual firing the empty cartridge cases being light can be thrown clear of the breech without injury to the mechanism. Drill cartridges are heavy and the extractor grasps only one side of the cartridge, and has a tendency to force the cartridge to the left. A slight binding is the result and a decided "yank" on the operating lever may break the lip of the extractor. In using drill cartridges, or cartridge cases for instruction purposes, should the block become jammed in the closed position, the following methods of removing cartridges are found to be the best in order to prevent injury to the mechanism: the use of a hammer and large copper drift will be necessary. Remove the firing lock case, the operating lever, and the carrier hinge pin. The carrier swings free. Place the heel of the copper drift on the lower end of the semicircular lug of the breech block, and by tapping with a hammer lightly, the block will disengage and can be removed from the breech recess. With a finger in the slot, cut in the extractor, give the extractor a pull from the rear, and remove the jammed cartridge. The use of a block of wood and hammer on the operating lever is another method, but there is danger of springing the teeth of the operating lever.

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To Assemble the Breech Mechanism

The breech mechanism is easily damaged. Care should be taken to jam no part of the mechanism or burr it in mounting. In assembling the breech mechanism, never lay carrier down hub up, and the slide block on, trusting to luck that you will come somewhere near the hole which the locking lug engages. Hold the carrier in one hand and the block in the other, then guide the block so that the lip on the semicircular lug will engage in the slot on the rear of the carrier hub. After doing this, rotate the block to the left until the block latch engages. One of the reasons for the block failing to function properly when mounted, is due to the fact that the operating lever is put in at an angle. The block must rotate a certain distance in order to unmask the firing pin. A small arrow will be found on the upper lug to which the operating lever is secured. Another arrow will be found on the operating lever near the point where the pivot key passes through the lever. Insert the toothed segment of the lever in the recess. Bring the two arrow points together and insert the pivot key. To assemble the contents of the firing lock case, the sear is first inserted by having the machined lug fit in the hole bored in the wall of the firing lock case. It will be found easy to guide it into the case by pressing on the lower point with the index finger. The firing spring is screwed on the firing pin so that the end of the spring with the small projecting point will rest at the rear of the pin. The sleeve is placed over this, and the point of the spring is inserted in the small hole in the left side of the sleeve. Place the point of the firing pin against a piece of wood and press the sleeve down, engaging it on the shoulder of the firing pin. Insert it shoulder first in the end of the firing lock case, lined so that the lift will engage in the sear. Before the pin is fully set, the trigger fork is inserted engaging the firing pin, with the rounded shoulders up. Push the firing pin into its seat. The trigger shaft is put in the other end of the firing lock case, and engages the hub of the trigger fork. The trigger shaft has two prongs on the end, one long and one short. It is assembled with the short arm parallel to the firing pin. Engage the trigger shaft detent. The firing lock case is inserted in the breech mechanism, the end rotating downward until the locking bolt snaps into its seat in the face of the carrier. Next, the extractor is inserted in the breech, with the extractor lip toward the muzzle and the center of the bore. The extractor lever is inserted in the side of the breech with the flat side to the front, engaging in the slot cut in the extractor. Place the carrier in position in the breech and insert the carrier hinge pin, making

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sure that hinge pin catch is properly seated in the end of the hinge pin.

The bracket (18), which is a bronze plate, is secured to the cradle by means of two stud screws and nuts, having at the front end an adjusting screw with check nut (9) for tripping the mechanism. The shaft (17) protrudes through the pallet shank (3) to which is pinned the firing pallet (1) on the recoil lug of the gun. The action is as follows: the trip latch (11), which is mounted in the firing handle

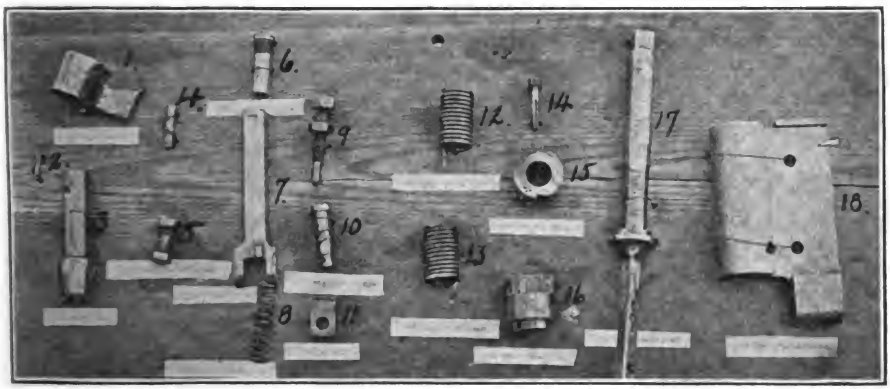

FIGURE 12. THE FIRING MECHANISM

1. Firing Pallet.
2. Trip Latch Pin.
3. Pallet Shank.
4. Pallet Pin.
5. Firing Handle Plunger.
6. Firing Handle Hub.
7. Firing Handle.
8. Firing Handle Spring.
9. Adjusting Screw and Check Nut.
10. Trip Latch Plunger.
11. Trip Latch.
12. Handle Return Spring.
13. Shaft Return Spring.
14. Tripping Collar Pin.
15. Tripping Collar.
16. Firing Handle Hub.
17. Firing Handle Shaft.
18. Firing Handle Bracket.

hub (6), engages the notch on the tripping collar (15). Pressing the firing handle (7) down rotates the whole mechanism, which brings the trip latch plunger (10) in contact with the adjusting screw (9) arresting its movement. Further pressure exerted on the handle causes the mechanism to rotate further disengaging it from the trip latch. The instant the trip latch (11) is forced from its seat, the shaft return spring (13), which has been compressed, causes the shaft (17) to return to its normal position, and the instant the pressure is removed from the firing handle (7), the handle return spring (12), which has been compressed, causes it to spring back into its normal position. This arrangement insures the shaft being in its true position to reëngage in the pallet shank (3) without injuring the mechanism the instant the gun returns to battery after being fired.

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To Dismount the Firing Mechanism

If it is desired to remove the mechanism from the cradle, the nuts on the screw studs can be removed, by using a small screw wrench or, if that is not available, the filling and draining plug wrench or the quadrant wrench. Of the latter two wrenches, the quadrant wrench would be the proper one to use. The cylinder end stud nut must be removed and the gun held out of battery about ten inches, in order to disengage the firing shaft. Remove the firing mechanism.

To Dismantle the Firing Mechanism

At the front end of the firing bracket will be found a split steel pin. Force this pin from its seat, and by pressing the firing handle down until the trip latch is lifted from its seat, the trip collar can be removed, following which the firing handle hub can be removed and then the handle return spring. The firing shaft is now ready to be removed together with its spring. (The difference between the shaft return spring and handle return spring is slight, and one is apt to be confused. Lay the two springs together and it will be noted that the handle return spring is slightly larger in diameter than the shaft return spring, also the prong of the handle return spring is longer than that on the shaft return spring.) To dismount the trip latch and plunger from the firing handle hub, a small taper pin which runs through the trip latch, engaging it to the plunger, is removed, and the trip latch can easily be disengaged allowing the plunger and the spring to drop out of its seat.

To Assemble the Firing Mechanism

Tools needed: 1 filling and drain plug wrench; 1 hammer.

First place the shaft return spring in its seat, with the short prong of the spring engaged in the slot of the shoulder in the center of the shaft channel in the firing bracket. Place the shaft in position, causing the long end of the spring to be inserted in the hole on the shoulder of the shaft. Place the square end of the filling and draining plug wrench over the whole of the shaft next to the shoulder, and return the shaft compressing spring until the slot cut in the shoulder of the firing shaft is seated over the check stud fitted in the firing bracket. Next, place the handle return spring in position, end of bracket engaging the short shoulder in the lower slot of the shaft channel, then slide the firing handle tub over the shaft, causing the long end of the spring to enter the slot cut in the hub. Place it

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in its seat and put on the trip collar. Replace the trip collar pin. In mounting the mechanism, be sure that a little oil is placed in the shaft channel.

To Remove the Pole

Tools required: 1 wrench, ¾ x ⅝ inch; 1 hammer; 1 large copper drift; 1 pair pliers.

First loosen the nut on the clamp on the left side of the pole clamp. Remove the pole clamp bolt. Next take out the small pins on each side of the pole clamp which hold the tie rods in position. With the pliers remove the split pin which holds the pole bolt in place. Remove the nut on the double tree strap bolt, lifting the strap clear of the double tree bolt. Remove the double tree. With the large copper drift and hammer, remove the pole bolt. The pole is now free to remove from the clamp, and if its ticks take a wrench and run through the neck yoke stop at end of the pole, twist the pole, and at same time pull from its seat.

To Replace the Pole

Insert the large end of the pole in the pole bracket, making sure that the holes for the pole bolts are in line for the holes in the bracket and that the neck yoke stop and neck yoke counter-stop are on the underneath side. Secure the pole bolt and nut with a split pin Replace the clamp bolt, nut, and split pin. Replace the double tree drawing the double strap down over the double tree bolt. Replace the nut on the double tree bolt and secure it with a split pin. Replace the tie rod fulcrum pin inserting split pins, spreading their ends to prevent losing them. The pole is replaced.

To Remove a Wheel

(Wheel Fastener Model 1902)

Tools required: 1 pair pliers; 1 cross-peen hammer; 1 steel punch; 1 screw jack.

To remove a wheel jack up the carriage until the wheel is clear of the ground. With the pliers compress the free end of the wheel-fastener hasp split pin and using the hammer and steel punch, disengage it from the hasp lug on the box. Raise the hasp, and holding the wheel stationary turn the wheel fastening until the lugs disengage (a turn of 90°) and remove the wheel from the axle.

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(Wheel Fastener Model 1911)

The wheel being clear of the ground, raise the hub latch causing the hub latch plunger to disengage from the hole in the hub band. Unscrew the hub cap turning it to the left. Raising the wheel fastener plunger, disengage it from the axle; after removing the wheel fastener, remove the wheel.

To Remove a Hub Liner

Tools required: 1 sledge hammer; 1 hub liner driving tool.

Place the wheel flat on a board or block with small end of the hub uppermost. Place the small shoulder of the hub liner driving tool in the hub, and use the sledge hammer to drive the hub liner from its seat. In replacing the hub liner, be sure the box is clear and the outside of the hub liner clean. To reset the hub liner, place the wheel so that the small end of the hub is downward, invert the hub liner driving tool, and holding a piece of wood over its small end (to prevent burring of the tool), drive the hub liner firmly into the box.

Road Brake

(Model 1916)

The brake on the 1916 caisson differs also from the 1902 model, being a band brake, and consisting of the brake drum, brake band, lining, brake band end, band clip, band guide, adjusting nut, and adjusting link. (See Plate XXI and pages 111–113.)

The action of the brake is as follows: When the lever is pulled up, the tension produced in brake lever shaft is communicated to the brake crank shaft, and through it to the brake cranks, these in turning pull the outer crank forward by means of brake rods. The outer cranks turn the brake shafts, which, by means of crank arms, on their outer end, draw the terminals of the brake bands closer together, clamping them tighter upon the revolving brake drums, thereby causing friction, thus retarding rotation of the wheels. (Use with Plate XXI, page 111.)

To Adjust the Road Brake

(Model 1902)

Tools required: 1 hammer; 1 small copper drift; 1 pair pliers.

Disconnect the brake rods from the brake beams. To do this remove the split pins which hold the brake rod fulcrum pins in place.

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Using the hammer and a small drift drive the fulcrum pins from their seats. Next, the brake shoes are placed with the desired clearance from the tire and the brake lever with handles in the released position. Now, either lengthen or shorten the full length of the brake rod by unscrewing or screwing up the forks on the ends of the brake rods, which gives the correct length for each rod to insure the proper functioning of the brake. Connect the brake rods to the brake beams, and replace the fulcrum pins and split pins. The brake is now properly adjusted.

The Bracket Fuse Setter

Study pages 53 to 55, inclusive, 3-inch Handbook.

In dismantling the bracket fuse setters be very careful not to break any pins or screws. The procedure described in the 3-inch Handbook should be followed exactly. Wear in the gears of the fuse setter, model of 1905-M, cannot be adjusted. In the 1916 model, the wear may be taken up by the adjusting screws. In this model, the range worm and the corrector worm fit through holes bored in the adjusting screws. When these are tightened they press the worms into the gears on the corrector ring and the range ring worm wheel, thus taking up any lost motion. The 1916 model bracket fuse setter has the same nomenclature as the model of 1905-M. In dismantling and assembling the model of 1916, the same procedure is undergone as with the model of 1905-M. Great care should be taken not to lose any of the set screws. In this model the corrector ring moves and the pointer arm fits in a small hole in the corrector ring. In the model of 1905-M the pointer arm moves. The model of 1916 is built very strongly, the corrector worm case is in the same casting as the base. In replacing the pins which secure the range worm crank handle and the corrector worm knob, care should be taken that they are placed properly in their holes. The pins and holes are tapered so that they cannot be reversed with respect to one another. The range ring when replaced must be put back so that the safety mark "S" is almost next to the rotating pin notch.

The Hand Fuse Setter

The procedure described in the 3-inch Handbook should be followed exactly. The function of each part and its relative positions should be demonstrated. In the 1905-M model the corrector and range are corelated because the range setting must be opposite the corrector setting. In the 1912 model they are separate

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In the 1912 model explain carefully the functions of the pointer arm, the index bar, and the index. The same precautions apply to dismantling and assembling the hand fuse setters as applied to the bracket fuse setters.

Shrapnel and Shell

Powder is divided into high and low explosives. Black powder and nitrocellulose are in the low explosive class. Dynamite, dunnite, and nitroglycerine are examples of high explosives. The low explosives are ignited and burn progressively; the high explosives are deteriorates, instantaneously detonated by the molecules striking against one another. The grains of nitrocellulose powder are cylindrical in shape with seven lengthwise perforations. They are constructed in this manner so that the burning surface will be increasing and the maximum amount of pressure will be exerted just before the projectile leaves the bore.

If the range is set at "S," no matter what the corrector is, the fuse cannot burn. The percussion fuse cannot arm in the bore of the gun because the projectile is being accelerated and the weight of the firing pin tends to unarm it and overcome the centrifugal force. After the projectile leaves the bore, it decreases its velocity and the balance between the centrifugal force and the inertia of the firing pin turns the other way thus arming the fuse. The fuse cannot arm when dropped on its side because of the two plungers which hold it in place. When one moves out the others move in. Ordinarily the centrifugal force would not be strong enough to hold the firing pin in place on impact, but the weight of the firing pin is to the left of the pivot and at the sudden jar of impact, this weight tends to move forward and helps to hold it in place.

To Dismount the Gun

In dismounting the gun the following tools will be used: 1 pair pliers; 1 wrench, ¾ x 1 inch; 5 bars of wood (pick handles are best).

The recoil indicator throw is removed from the dust guard by use of pliers. Next, remove the cylinder and the stud split pin. Now bring the gun to zero elevation and remove the cylinder, stud, and nut, using a large wrench. Push the gun out of battery about a foot and have two men with pick handles engage them behind the recoil lug of the gun. Move the gun to the rear slightly in order to allow other men to place pick handles under the tube. Care should be taken that the gun be kept level, not allowing the breech end to drop, else the guide rails will be crimped, thereby disabling the

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carriage. As the gun slides off the cradle the dust guard is brought with it, and is removed, allowing the last two men to engage their pick handles under the tube, just in front of the front clip. Place the gun wherever desired.

To Dismount the Recoil Mechanism

Tools necessary: 1 block and tackle; 1 spring compressor; 1 wrench, ¾ x 1 inch; 1 filling and draining plug wrench; 1 pair pliers (wire cutting), 10 inch; 1 cylinder head and gland wrench.

Before removing the cylinder and stud nut, the piston rod nut should be loosened. With the pliers, remove the piston rod nut split pins. Then with use of a large wrench loosen the nut. If the nut is found to be jammed or rusted, soak threads with kerosene oil and use a large wrench, tapping it slightly with a block of wood in order to loosen it. Next, remove the cylinder end stud split pin and nut, securing the gun so that it will not slide from the carriage. Place three men in convenient positions making sure of a direct line with the access of the cradle, and the stationary object to which the carriage is attached. Set the brakes and chock both wheels of the gun to prevent rearward motion. Now remove the retaining ring hasp split pin, swinging the hasp clear of the lug on the cradle head. Take off the piston rod nut. Then with the cylinder head and gland wrench (commonly called "one lunger"), remove the cradle head, attaching spring compressor to the cylinder end stud, and it in turn to the block and tackle. Have about eight men to take up tension of the springs from the retaining ring. Use the filling and drain plug wrench to loosen the nuts on the retaining ring bolts, swinging them aside. Then remove the retaining ring. **No part of the body should be exposed in front of the cradle while this work is going on.** Allow the pressure to be released by easing up on the tackle. The springs and cylinder will counteract. After pressure has been released to where the spring compressor is slack, detach same from the block, and remove the cylinder with one spring, until cylinder end stud is brought out of cradle at front end. Now remove the spring compressor and the other springs in the cradle. (2 of old model, 4 of new model.)

To Assemble the Recoil Mechanism

Tools required: 1 spring centering tool; 1 spring compressor; 1 block and tackle; 1 filling and drain plug wrench; 1 cylinder and gland wrench; 1 grindstone recoil spring wrench; 1 pair pliers.

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With the cylinder filled, the cylinder head and gland properly wired in place, to mount recoil mechanism; put two recoil springs in the cradle (so that the spring compressor runs through their center) being sure they have been cleaned of grit and properly oiled. Then put the spring support guide on the cylinder with the guide lugs pointing toward the rear, slide the third spring on the cylinder and pass it through the center of the spring, attach spring compressor to the cylinder, and take up slack in the spring compressor. Attach the spring compressor to a block and tackle. (Caution: Make sure that the gun is secure, wheels properly blocked, and brake tightened.) After making sure that the axis of the cradle is in direct line with the object to which the block and tackle is attached, put a sufficient number of men on the rope to compress the springs in the cradle. Keeping the body clear, take the counter-recoil spring and grindstone wrench, and engage two lips in convenient holes in bottom of the spring support guide. It will be found that the front end of the cylinder will have to be lifted slightly in order to let the guide lug engage in the slot. (Caution men to pull slowly when the spring support is nearing the cradle.) Place the retaining ring in the end of the cradle. Swing the retaining ring bolts in place and tighten up both nuts, using filling and drain plug wrench. Ease off, allowing the spring support to rest against the retaining ring. Detach tackle. Attach the cradle head, and with the hand, screw on the piston rod nut. (In mounting the recoil mechanism care should be taken to keep the drain plug up.) Next, remove the spring centering tool. Be sure that the hole in the cylinder end is convenient for the free admittance of the cylinder centering lug in the recoil lug of the gun. Push the gun into battery attaching the cylinder end stud nut by means of a three-quarter by one-inch wrench. Replace split pin. Now with large wrench tighten the piston rod nut, putting in split pins to hold it in place. Place split pins in the retaining ring bolts to hold nuts in place. The mechanism is mounted.

To Fill the Cylinder Mechanism Mounted

Elevate the gun to its maximum elevation. Remove the piston rod nut. Take off the cradle head. With filling and drain plug wrench remove the drain and filling plugs. Insert end of a funnel and fill the cylinder through front end of the piston rod. If no screen is soldered in the funnel for straining oil, use a piece of clean cheesecloth, and with a cup dip oil and pour it in the cylinder until the cylinder is flooded. Allow oil to settle. Then take out about

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two gills, depressing gun to accomplish this. After the proper amount of oil is removed, elevate the gun replacing the filling and drain plugs. Replace the cradle head. Attach the piston rod nut securing same by the means of two split pins. Secure the cradle head by means of the retaining ring hasp and split pin. The cylinder is filled.

To Drain the Cylinder while Mounted in the Carriage

Tools required: 1 wrench, ¾ x 1 inch; 1 pair pliers, wire cutting; 1 cylinder head and gland wrench; 1 filling and drain plug wrench.

Remove the piston rod nut split pins. Remove the retaining ring hasp, wring the retaining ring hasp clear. With a cylinder head and gland wrench remove the cradle head. In order to expedite this work it would be well to loosen the cylinder end stud nut, in order to allow the cylinder to be turned over. Bring the gun to zero elevation. Loosen the filling plug and remove the drain plug. Be sure to have clean receptacle for catching the oil. Depress the gun as needed in order to allow free flow of oil.

To Dismount the Cylinder

If it is desired to dismount the cylinder only, the gun should be put at zero elevation using the following tools: 1 wrench, ¾ x ⅝ inch; 1 pair pliers; 1 screw driver; 1 filling and drain plug wrench: 2 cylinder head and gland wrenches.

Remove the piston rod nut and cradle head. Remove the cylinder end stud nut. Be sure to secure the gun to carriage. Pull the cylinder from the cradle. Place the cylinder on two wooden horses or boxes, and drain the cylinder by removing the filling and drain plugs. Next, with one cylinder head and gland wrench engage the cylinder, engaging a second wrench to the cylinder head. and unscrew the head. It is not necessary to remove the gland unless it is desired to remove the packing. Remove the piston rod. The cylinder is dismounted.

To Assemble the Cylinder

Make sure that the cylinder is clean. Insert the piston rod in the end of the cylinder, pushing it gently until the piston engages with the throttling bars. Hold the piston rod centered while putting it in the cylinder. Screw on the cylinder head and gland. Wire the cylinder head with copper wire to the lugs on the shoulder of the cylinder. Wire the gland to the cylinder head. Fill the cylinder by tilting, placing cylinder end on floor. Replace the filling and drain

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plugs, wiring the drain plug in its seat. Place the cylinder in the cradle. Secure the gun to the cylinder by the cylinder end stud nut. Replace the cradle head securing same, putting on the piston rod nut. Wire the filling plug to the split pins on the piston rod nut.

To Dismount the Cradle

To dismount the cradle the following tools will be needed: 1 wrench, ¾ x ⅝ inch; 1 screw slot wrench; 1 pair pliers, wire cutting; 1 steel punch; 1 hammer.

The gun and recoil mechanism being dismounted, remove the elevating split pin and take out the elevating pin. Then elevate the cradle to its maximum elevation. Next, remove the traversing handwheel, by removing the split pin securing same to hasp, and sliding the wheel off end of the shaft. It would be well to remove the worm gear to keep from damaging it. With the ¾ x ⅝ inch wrench and screw slot wrench remove the split pin and traversing link pivot nut allowing the traversing link pivot to drop from its seat. The cradle is now free. Next, with ¾ x ⅝ inch wrench remove the nut from the bolt on the center clamp to which the left seat support of the right axle seat is attached. Raise a corner of the axle seat up. Now swinging front end of the cradle to the right and under the axle seat, the lug of the cradle pintle will disengage with the guide lugs of the pintle socket, and at the same time the rear cradle clip will disengage from the traversing plate. Raise the cradle until the pintle is free of the bearing, passing the cradle out to the front. Care should be taken to keep the cradle guide rails from striking against any part of the carriage. Otherwise they will become burred.

Part II

Note:—Unless otherwise noted, all references in **Part II** are to pages in the Handbook of the Br. 75 mm. Gun matériel

The 75 mm. Gun Carriage British Model 1917

The carriage is constructed to allow 16° elevation and 5° depression of the gun. It is fitted with a recoil mechanism which is held in a cradle above the gun. The recoil mechanism consists of a hydraulic buffer to limit the length of the recoil, and eight counter-recoil springs. The carriage is also constructed so that the gun can be elevated for range without elevating the line of site. There is

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also an automatic corrector for drift. The cradle is inclined at an angle of 1½° to the left side, the left trunnion being the lower. As the gun is elevated the muzzle moves to the left, automatically correcting for the drift of the projectile, which is to the right. (For weights, etc., see page 26, Handbook of the Br. 75 mm. Gun matériel.)

The Trail

The trail is tubular and is fastened to the axletree by the axletree bracket, which also forms a pivot for the carriage body. The rear end is fitted with a spade, lifting handles (for lifting the trail), trail eye (for connecting the gun carriage to the limber), and a traversing lever (for shifting the gun to the right or left). This traversing lever is bolted to the traversing lever bracket and has a pawl held by a spring, which engages a notch on the bracket when the traversing lever is in the operating position. The pawl is released by a pressure of the foot on a pedal when it is desired to return the lever to the traveling position. The lever in the traveling position is held by the traversing lever securing clip which is fastened to the trail slightly in front of the spade. (Study Plate XVI, page 35.)

In front of the securing clip the locking band is shrunk on, and acts as a wheel guard to prevent the tire from cutting the trail in sharp turns.

In front of the locking band is a brake band which supports the brake arms, and the rear end of the tie rods which brace the axletree.

In front of this is the traversing bracket. This has a dovetailed projection on which the rear end of the carriage body rests and it also acts as a bearing for the body while traversing.

Forward of this is the traversing gear band which has in its upper side a stud called the clamping gear stud, by means of which the carriage body is locked to the trail in traveling.

On the front end is the axletree bracket, through which the axletree passes and is fastened by a pin.

The rammer staff is placed inside the trail from the front and carried there, the end of the trail being closed by a door.

The Carriage Body

The carriage body consists principally of two triangular-shaped side pieces (1), connected by transoms (2). An oblong transversal hole is cut through the front end, through which the axletree (3) passes. A bronze bearing (4) is fitted in each side of this hole, and it is on these that the carriage body swings on the axletree (3). The

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inner ends of these bearings are cut into a segment of a circle, and the axletree bracket (5) being formed in the shape of a circle on the upper side of the axletree, the bearings grip it and prevent any motion to the front or rear. A bracket is fitted to the rear end of

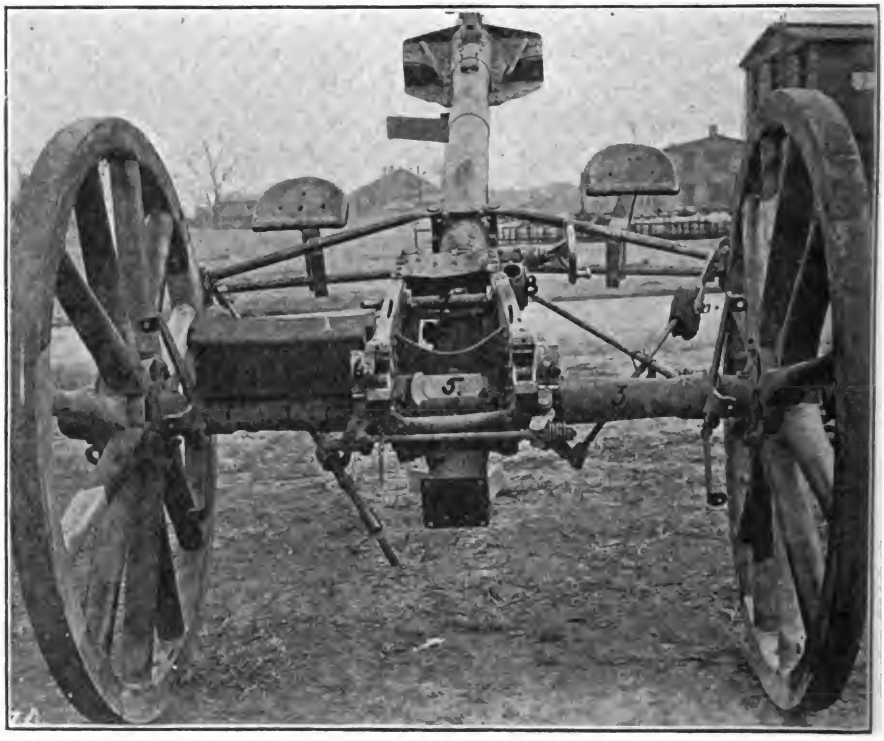

FIGURE 13. THE LOWER CARRIAGE

the body having two "L" shaped projections downward which engage with the dovetailed projections on the traversing bracket.

On the top of the front end are fitted two bearings (6) for the trunnions of the cradle. These bearings, called the trunnion bearings, are inclined backward at an angle of about 45° with the horizontal. They are fitted with caps which are easily removable when it is desired to remove the cradle.

Two projecting lugs at the rear of the body and on the right side are the means by which the traversing gear is bolted to the body. Passing through the body and operated by a lever (7) on the right side are placed two semicircular clamping pieces which engage with two like pieces on the cradle when the shaft is turned, and thus lock the cradle to the body.

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On the left side of the body is bolted the case for the lower elevating gear.

The Cradle

The cradle is cast of bronze with steel trunnions to pivot it to the carriage body. The left trunnion is prolonged and threaded for the reception of the rocking bar sight stud. It has a circular passageway longitudinally, through which the gun slides in recoil, and two recesses are formed in the upper side of this passageway, in which the guides of the gun slide, to steer the gun in recoil and counter-recoil.

A steel guard is fitted to the left side to protect the gunner on the left axletree seat.

A collar projecting upward from each end is threaded to receive the outer spring case, which screws into it.

The elevating handwheel and range indicator shafts run transversally under the outer spring case.

The case for the range elevating gear and the range gear arc are attached to the left side.

The Axletree and Wheels

The axletree is a tubular steel forging; it passes through the axle-tree bracket on the trail and is secured there by a pin through the bracket and axletree. Two brackets, one on either side of the carriage body, are held also by pins. These press against the carriage body bearings and help to prevent the lateral motion.

The spokes are so arranged that they give a very strong truss-like construction to the wheel. With the wheel standing perpendicular, the alternate spokes are perpendicular to the axle; the other spokes are so arranged that the hub end of the spoke is about an inch and a half farther in toward the middle of the axletree. (See Fig. 13.) The felloe end is on a line with the other spokes, making these last angle outward.

The axletree ends are bent slightly downward, so that, as the wheel is placed on the axletree, the first spokes slant slightly inward, and the second slant outward, forming a "V" bracing the wheel from side thrust from either direction.

The Shield

The shield is in three parts: the main shield (1), top shield (2), and apron (3). It is made entirely of armor plate.

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The main shield is attached to the axletree by two supporting axle brackets, and to the trail by a flange. A sheet steel case (4) with leather bound packing blocks is attached to the rear face on the left side of the carriage. It is called the panoramic sight case and

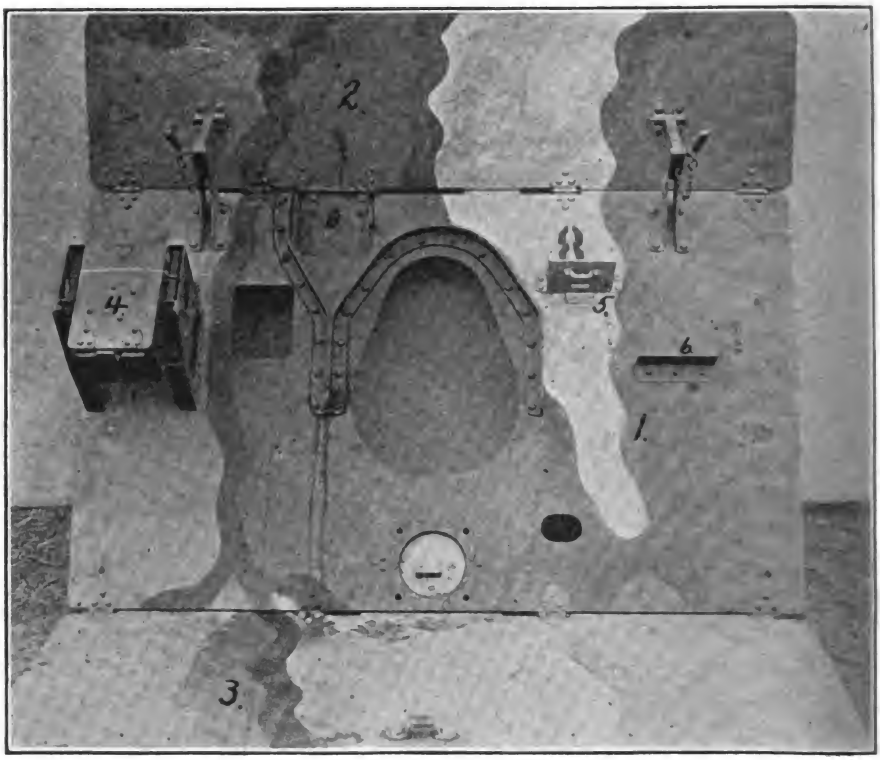

FIGURE 14. THE SHIELD

1. Main Shield.
2. Top Shield.
3. Apron.
4. Panoramic Sight Case.
5. Oiler Bracket.
6. Tool Box Bracket.
7. Rocking Bar Sight Port.
8. Shutter.

it is the carrying place for the panoramic sight in traveling. A leather spare parts case is fastened to the right axletree, and higher up on the shield on the same side is a bracket for carrying the horizontal oiler (5). A tool box is also fastened on this side (6). A hole (7) is cut through the shield on the left side through which the rocking bar sight passes. Another hole or port for use in sighting to the front with the panoramic sight is provided on the same side; this is provided with a hinged shutter (8) so that it may be closed.

The apron (3) is hinged to the lower edge of the main shield. It

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swings up and to the rear in traveling and is secured by a pawl with a releasing lever, and a pin which locks it tightly in traveling.

The upper shield (2) is hinged to the upper edge of the main shield. It is so arranged that it may be lowered in traveling, or when desired to sight over the top of the main shield.

The Traveling Locks

A cross spindle is fitted solidly to the carriage body. This spindle is turned by a lever on the right side of the body and is fitted with two semicircular bosses (one on either side) which engage with two semicircular seats. Elevated and the handle turned, the lugs on the spindle engage those on the cradle and solidly lock the two together. Two stops are fitted to the carriage body to limit the movement of the handle. In the event of the gear becoming jammed, the elevating handwheel on the left side should be turned toward the front slightly so as to depress the gun and ease the lock.

A stud projecting upward from the rail fits through a slot on the carriage body. An octagonal nut is placed on this stud and a hand lever attached to the nut projects out of the carriage body to the right. When the hand lever is pulled to the rear, the nut is screwed down on the slotted bracket, and clamps the carriage body and trail together. The lever is prevented from working forward by a pin placed in one of a series of holes on the adjusting arc (on the right side of the body).

When the clamp becomes worn and the nut does not screw down far enough to clamp the body and trail together, the handle should be moved around on the nut one width of a turn. This should be sufficient to tighten the clamp.

Sights

The instruments for sighting and laying the piece consist of a rocking bar sight and a panoramic sight.

The rocking bar sight consists of a rocking bar (1) and a sight bar (2). The rocking bar is pivoted horizontally at the front end to an arm on the left cradle trunnion. At the rear end it is fastened to the range arc bracket by an open square socket (3) on the bar which fits over an arm on the bracket.

A bracket is riveted to the under side at the rear, to which is attached the angle of sight device (4). The rear end is fitted with a cross head in which works a traversing screw with two milled heads (5). By the use of a nut on the sight bar, ninety mils of deflection to right or left may be set off.

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The sight bar is pivoted vertically about its center to a socket, with an adjustable bushing on the top of the rocking bar. The rear end of the bar is attached to the traversing nut (6). The nut on the traversing screw is in two halves and fitted with a spring so as to take up any back lash, due to wear in the screw. The front end of the bar is fitted with a projecting point or front sight with a removable protecting cover (7) and the rear is fitted with a notched projection as a rear sight (8). The entire rocking bar and sight bar is removable, being attached to the carriage by two nuts.

The angle of sight device consists of a level bracket, with leveling screw and a level holder, trunnioned to the upper part of the bracket.

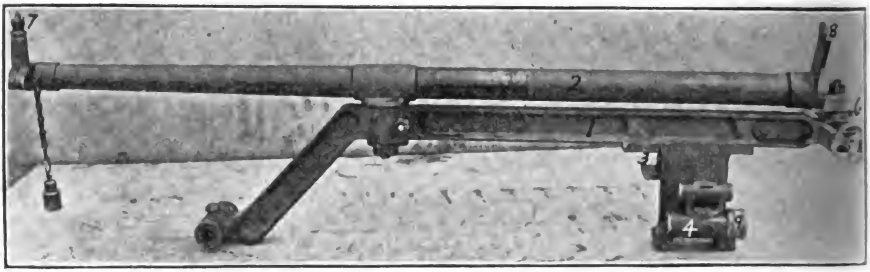

FIGURE 15. THE ROCKING BAR SIGHT

To the rear end of the leveling screw is attached the micrometer disk (9). This is graduated into 100 divisions of one mil each. The level holder has a toothed segment, meshing with the leveling screw and is marked 2, 3, 4, 5, opposite an index line on the bracket. Each of these graduations is equal to one turn of the micrometer screw. The numbers 2, 3, 4, 5, stand for 200, 300, 400, 500 mils; 300 is the normal or level line of site.

A bracket fastened to the range gear arc is fitted with a socket in which is placed the panoramic sight carrier. A clamp lever is attached by which the holder is clamped into place. The holder is provided with a slot in which the projection on the back of the sight slides.

The sight used is the panoramic sight model 1917. (See Plate XXXI, page 75, 75 mm., Model of 1917 (British) Handbook.)

The Recoil Mechanism

The recoil mechanism, consisting of an oil hydraulic buffer and the counter-recoil springs, is suspended in the cradle. The buffer consists of a cylinder (1), piston rod (2), and piston (3), control plunger (4), stuffing box (5), and gland (6).

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The cylinder is made of steel and is about 2¾ inches in diameter. It is closed at the rear by the cylinder head and the control plunger. The front end is closed by a brass stuffing box and gland which screw into it and are secured there by a spring stud (7). A collar about an inch larger in diameter than the cylinder is formed near the front end, against which the inner counter-recoil springs (8)

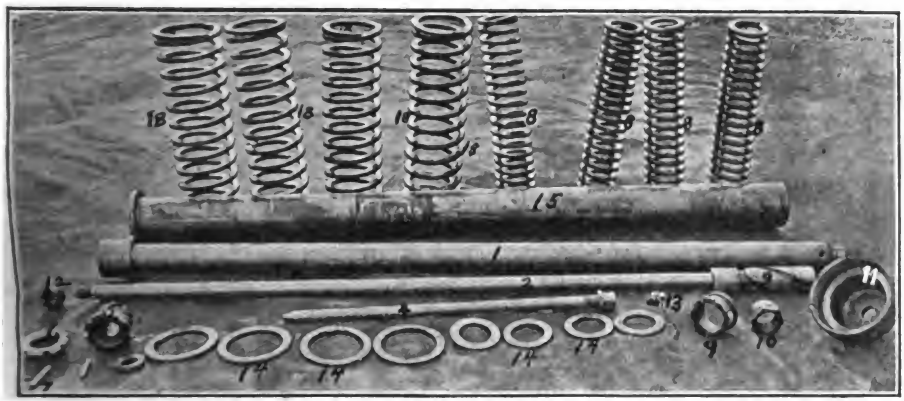

FIGURE 16. THE RECOIL MECHANISM

1. Buffer Cylinder.
2. Piston Rod.
3. Piston.
4. Control Plunger.
5. Stuffing Box.
6. Gland.
7. Spring Stud.
8. Inner Recoil Springs.
9. Inner Nut.
10. Outer Nut.
11. Outer Spring Case Cap.
12. Piston Rod Nut.
13. Filling Plug.
14. Parting Plates (inner and outer).
15. Inner Spring Case.
18. Outer Recoil Springs.

press. Ten longitudinal grooves are formed on the inner walls of the cylinder. The depth of these grooves varies, so that the space between the piston and the cylinder walls for the passage of oil varies during recoil. The graduations are such that there is maintained an approximately constant pressure as the gun goes back in recoil and insures steadiness of the entire carriage.

The rear end of the head is slightly smaller than the cylinder, and is threaded for a short distance. A hole, closed by a plug, is provided in the upper side of the head. Two keys in the head which engage in slots in the recoil lug of the gun prevent the cylinder from turning, and it is held firmly from any movement forward or back by the inner (9) and outer (10) nuts.

The piston rod is steel, and has attached to it a piston. This is made from a solid block of bronze and there is very little clearance between it and the cylinder walls. It is so machined that there is a collar about two inches wide formed on the forward end. In rear of this a groove is cut all the way around the piston. In rear of the groove the piston is again of normal size, but has three spiral grooves

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about ½ inch wide cut around it all the way to the end. The design of these grooves is such as to act as an additional brake to the passage of the oil past the piston by creating a centrifugal flow of the oil and causing it to again change direction as it passes into the longitudinal grooves.

The piston rod is bored out in the rear end to form a recess for the control plunger. The front end of the rod is fastened to the outer spring case cap (11) by the piston rod nut (12).

A hole for filling the cylinder with oil is placed on top of the cylinder head. A filling plug (13) attached to the cylinder with a chain to prevent loss is provided.

Buffer oil is used and it takes about 4.5 pints to completely fill the cylinder.

The control plunger is a steel rod about twenty-six inches long which screws into the rear of the cylinder head. The end is pointed and it has two slightly flattened sides, the flats tapering gradually out towards the rear. The rear end is fitted with a hexagon nut head on which a wrench may be used to screw it into place.

A washer is provided between the end of the cylinder and the nut head to prevent escape of oil.

A hole is bored in the rear of the control plunger and threaded in to which the spring compressor may be attached.

The counter-recoil springs surround the cylinder and consist of two sets of four each, called the inner (8) and the outer (18) springs. They are made of flat spring steel coiled on edge and the four inner springs slip directly over the cylinder. These springs are all prevented from coming into direct contact with each other by steel washers called parting plates (14). A hollow steel case, called the inner spring case (15), slips over the inner springs. This case has an inward projecting shoulder at the rear and an outward projecting shoulder at the front end. The outer set of four springs slip over the inner spring case and rest against the front shoulder. The inner set rest against the inward projecting shoulder at the rear.

The outer spring case screws semi-permanently into the cradle, and provides a housing for the entire recoil mechanism, which is placed inside of it after the case is in position. This case has an inward projecting collar at the rear, against which the outer springs press when assembled. It is closed in front by the outer spring case cap which screws on to it and is held from turning off by a cotter pin. A hole in the cap allows the passage out of the front end of the piston rod, which is secured from turning by a key. Any forward movement is prevented by a shoulder on the rod, and any movement to the rear by the piston rod nut.

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To detect any leakages of oil from the buffer cylinder, a number of holes are drilled in the two spring cases, through which any oil, which may have leaked from the cylinder, will run out and be noticed.

The Brake Gear

The tire brake is for intermittent use in traveling and is always used when the gun is firing. It consists principally of two brake arms, two cranked levers, connecting rods, and an actuating screw. The brake arms are pivoted to a bracket on the trail, and are provided at the other end with a cast-iron brake block and shoe, which acts on the wheels. Each of the cranked levers is pivoted to brackets on the axletree, one on each side of the carriage body; one arm of each lever is connected in front of the axletree by a connecting rod. The outer arm of the right hand lever is provided with a nut through which the actuating screw passes, the other end of the screw being attached to the right hand brake arm. The other arm of the left hand cranked lever is connected to the left hand brake arm by a rod and an eccentric link; a releasing lever, with an eccentric pivoted to the rod, and link enable the brake to be quickly released when desired. The brake arm is operated by the hand lever, the crank on the front end of the actuating screw, or the cross handle on the actuating screw in front of the right brake arm.

A spring placed so as to be compressed between the left hand cranked lever and the connecting rod prevents unequal setting of the two brake blocks, and insures even pressure on each wheel.

The Firing Gear

(See page 37, and Plate XIV, page 35, 75 mm. Handbook.)

The firing gear is so arranged that the cannoneer can fire the gun without altering his position in laying. It is attached to the left side of the cradle and consists principally of a connecting rod, connecting arm, and a spring lever which engages the trigger on the gun. The connecting arm is pivoted to a fulcrum on the cradle at one end; the other end is connected to a spring lever by the connecting rod. This connecting rod is provided with a handle by which the gear is operated. After firing, the handle is returned to the normal position by a spring attached to the lever and the shoulder guard of the gun. The gun can be fired when within two inches of the "In Battery" position.

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Action of the Recoil Mechanism

When the gun is fired the force of the explosion drives it to the rear. The projecting recoil lug, being attached to the buffer cylinder, draws it to the rear. The piston rod is held stationary by the outer spring case cap and the cylinder slides back over the piston. Being completely filled with oil, it would be impossible for the cylinder to move unless there was some way for the oil to pass from one side of the piston to the other. The grooves in the cylinder wall allow the passage of this oil. They are shallow at the front end and gradually taper slightly deeper at the rear, offering a varying space for the passage of oil and consequently a varying resistance to the movement of the piston. (See Plate XV, page 36, 75 mm. Handbook.)

The shoulder on the front end of the cylinder compresses the inner counter-recoil springs between it and the inward projecting shoulder on the inner spring case. As these springs are compressed, they force the spring case to the rear, it compresses the outer springs, which lie around it, between the shoulder on the front end of the case, and the rear end of the outer spring case. This outer spring case, being screwed solidly into the cradle, cannot move to the rear, so, as the gun continues to move the springs are compressed more and more and offer a constantly increasing resistance to the rearward movement of the gun on the cradle.

The resistance of the oil in the cylinder to passing from one side of the piston to the other and the increasing resistance of the springs combine to overcome the energy of the gun in its rearward movement, and bring it to rest after moving to the rear from forty to forty-nine inches.

It will be noticed that the depth of the grooves in the cylinder is greater at the rear than at the front end, offering easier passage for the oil, and consequently less resistance to the movement of the cylinder. The depth is graduated in such a manner that as the compression of the springs becomes greater, and offers more resistance to the movement, the resistance offered by the buffer becomes correspondingly less, keeping the total resistance approximately the same through the entire movement of the gun. Because of this fact the carriage remains very stable during recoil.

As soon as the combined resistance of the buffer and counter-recoil springs have overcome the energy of the gun and stopped the rearward movement, the compressed springs force it back to the normal firing position. The outer springs press on the shoulder of the inner spring case, forcing it forward. This case in turn presses

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against the inner springs, and they, pressing against the shoulder on the front end of the cylinder, force it back to the normal position, drawing the gun back on its slides into battery.

As the cylinder moves back over the piston, the oil must again pass from one side to the other through the grooves, and in doing so, it again offers a resistance to the movement. This time the resistance is increasing as the movement continues, for the grooves become shallower as the piston nears the normal position in the rear end of the cylinder. This increasing resistance prevents the counter-recoil springs from bringing the gun back into battery with too great speed, and gradually slows it down as it nears the normal position.

The gun would still return to battery with enough jar to move the carriage and make it necessary to completely relay it, if it were not for the control plunger. When the gun has returned to within about twenty inches of the normal position, the control plunger enters the hollow end of the piston rod. The hole being completely filled with oil, the plunger must force it out before it can enter. The only exit for this oil is over the flattened sides of the plunger, and as these flattened sides taper out, and the space for the escaping oil becomes less, there is another increasing resistance, which is sufficient to bring the gun gently to rest in the normal or "In Battery" position.

A description of the straps and their uses can be found on page 46, Handbook of the Br. 75 mm. Gun Matériel.

Description of the British 75-mm. Gun and Limber

The Gun

The gun is built up of alloy steel, consisting of a tube, a series of layers of steel wire, a jacket, and a breech ring. The tube extends from the rear end of the tube, and extending to the muzzle. Around the jacket, over the rear end of the projectile, when in the gun, are wound 15 layers of 0.04 by 0.25-inch steel wire. The jacket is fitted over the tube and wire, extending the entire length of the tube, and prevented from sliding to the rear by two shoulders formed on the tube just in front of the wire, against which two corresponding shoulders on the tube abut. The breech ring is screwed into the jacket from the rear and is held from turning off by a set screw. The part of the breech ring projecting inward bears against the end of the tube, preventing the jacket from sliding forward, and thus holding the entire gun together.

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On the upper side of the breech ring is a projecting lug called the recoil lug, by which the gun is connected to the recoil mechanism. Projections on the top of the jacket form guides on which the gun slides in recoil and counter-recoil. A plane for a clinometer is formed on the upper surface of the breech ring. Vertical and horizontal axis lines are cut on the muzzle and the rear face of the breech ring. The bottom of the grooves is cut round so as to make them easily cleaned. The breech ring is fitted for the reception of the breech mechanism.

The Elevating Mechanism

The elevating mechanism consists of the elevating gear and the range gear. It is so arranged that the elevation of the gun for range can be changed without changing the line of site.

Both gears operate on a double ended screw (9), called the elevating screw. The upper half is the range screw, and the lower half the elevation screw. In the middle, and projecting out at right angles, is an arm called the connecting rod arm (9a).

Fastened to the left side of the carriage body is a cup-like case, called the lower carrying bracket (Fig. 13, No. 8), for the elevating gear. It has an oval hole through the top and bottom through which the elevating screw passes. Screwed on to the bottom of the carrying bracket is a tubular protecting cap (16) which protects the projecting screw from dirt. Inside the bracket, and threaded so as to screw over the elevating screw, is the elevating screw nut (10). This is made in the shape of a large steel spool, and the lower side of the upper rim is cut into a bevel gear. Fitted closely inside the bracket and round the nut, so as to prevent any vertical motion, is the elevating nut bearing (15). This is made of bronze, and is so designed that the nut turns freely in a horizontal plane, but cannot move up or down. A hole is bored vertically through the bearing to allow the screw to pass. The screw hole in the bracket is cut slightly oval, and as the bearing will turn, the screw has some movement back and forth to conform to the radial movement of the gun as it is elevated with the cradle trunnions as a pivot. A groove is cut in the elevating gear screw and a key formed on the inside of the hole through the bearing fits into it and prevents the screw from turning.

Over the bracket, and closing the open side, is screwed the lower bracket cap (14). A projecting tube is formed on the cap which acts as a bracket, or housing, for the elevating handwheel shaft (17). Two bearings for the shaft are fitted in the inside of this

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projection and they are provided with oil holes closed by screws. On the inner end of the shaft is fitted the elevating screw nut bevel pinion, and on the outer end, the elevating handwheel (18). When the cap is screwed into place, the bevel pinion is held tightly up against the elevating screw nut (10), and the teeth of each intermesh. The outer end of the shaft is squared, and a squared hole in the handwheel fits over it, and is held tightly in position by a nut.

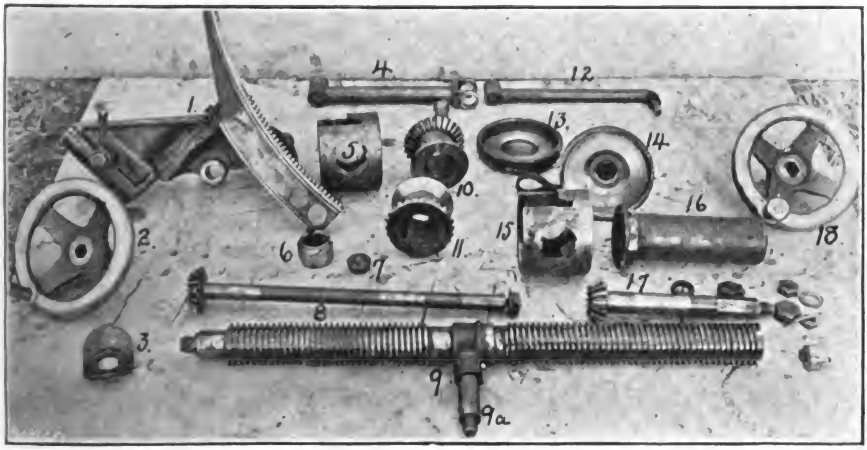

FIGURE 17. THE ELEVATING MECHANISM

1. Range Gear Arc.
2. Range Handwheel.
3. Cover.
4. Connecting Rod.
5. Range Elevating Nut Bearing.
6. Range Screw Collar.
7. Handwheel Nut.
8. Range Shaft.
9. Elevating Screw.
9a. Connecting Rod Arm.
10. Elevating Screw Nut.
11. Range Elevating Nut.
12. Firing Handle Connecting Rod.
13. Range Arm Bracket Cap.
14. Lower Bracket Cap.
15. Elevating Nut Bearing.
16. Protecting Cap.
17. Elevating Handwheel Shaft.
18. Elevating Handwheel.

The action of the elevating gear is as follows: When the handwheel is turned, the bevel pinion on the end of the handwheel shaft turns the elevating screw nut. This, being threaded on the inside and having the elevating screw screwed through it, tends to screw up or down on the elevating screw. The nut bearing prevents any up or down movement, so as the nut is turned, the elevating screw is forced up or down.

A steel rod, called the connecting rod (4), connects the arm on the elevating screw to the range gear arc (1). This arc or rack has teeth cut in one side, and a bracket fitted to it provides a seat for the panoramic sight carrier. The sight carrier is detachable and held in place by a clamp. It can be raised enough so that the line of sight can be directed over the shield.

On the upper half of the double ended screw the range gear

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operates. A range gear carrying bracket fastened to the left side of the cradle, and very similar to that for the elevating gear, holds a range elevating nut (11) and bearing (5) like that of the elevating gear. These operate in the same manner, except that the shaft enters the bracket from the opposite side. The shaft (8) passes transversally through the cradle under the outer spring case. Bearings for the shaft are fitted in the cradle. A handwheel, called the range handwheel (2), is fitted on the shaft on the right side of the cradle.

A shaft or spindle is fitted transversally across the cradle in front of the range handwheel shaft, bearings being provided for it also in the cradle. The left end of this spindle carries a pinion which meshes with the teeth on the range gear arc. The end projecting through the right side of the cradle is fitted with a wheel or dial called the range drum. This drum is graduated on its rim into meters and on its periphery, into mils. The drum is held on the spindle by two woodite washers. The washer on the inside bears against the drum and a spring case and the outer one between the drum and a jamming plate secured by a nut. By loosening the nut the drum may be turned around on the spindle, and any necessary adjustments made. The spring case contains a clock spring held between the spindle and a spring case so that as the spindle turns the tension of the spring prevents any backlash or lost motion.

The operation of the range gear is as follows: When the range handwheel is turned, the bevel pinion on its end turns the range nut. The hole through the nut is threaded, and as the screw is held solidly from rising, the nut screws up on the screw, raising the rear end of the cradle with it.

As the cradle rises, the pinion on the left end of the range ring spindle, being in mesh with the range gear arc, turns, and with it turns the spindle and range drum. An index fastened on the cradle indicates the angle of elevation in mils, and also the corresponding range in meters.

The Traversing Gear

The traversing gear consists principally of a cross head, a link nut, an actuating screw, and a handwheel.

The cross head (4) is a hollow steel tube with an inward projecting shoulder at one end and a lug formed on the bottom in the center and projecting downward at right angles. This projecting lug (4) is called the cross head pivot (4a). It passes through the traversing bracket on the trail and, by threads and a nut on the

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end, secures the cross head to the traversing bracket. Screwed on the cross head over the link (7) is the cross head dust cap (4b). This is a nut which acts as a gland and holds a small amount of cotton waste around the link to prevent dust from entering the cross head.

The link (7) is a bronze tube, machined to a close fit inside the cross head, closed at one end and drawn out flat, and threaded in the open for a short distance. The flattened end is bored through to admit a pin, called a link pin (8), which connects the traversing gear to the two projecting lugs on the rear of the carriage body.

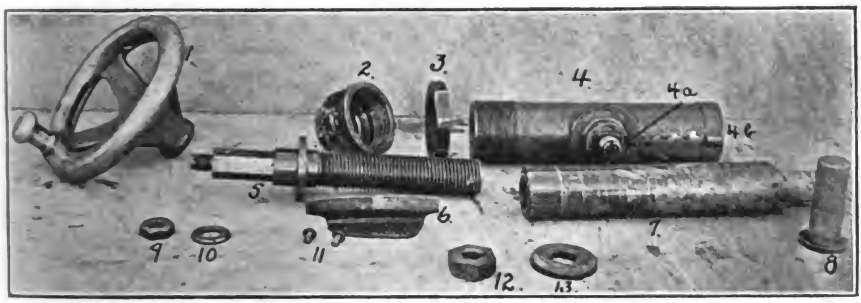

FIGURE 18. THE TRAVERSING GEAR

1. Traversing Handwheel.	4b. Cross Head Dust Cap.	9. Handwheel Nut.
2. Cross Head Cap.	5. Actuating Screw.	10. Handwheel Nut Washer.
3. Check Nut.	6. Traversing Scale.	11. Traversing Scale Screws.
4. Cross Head.	7. Link.	12. Cross Head Pivot Nut.
4a. Cross Head Pivot.	8. Link Pin.	13. Pivot Nut Washer.

The actuating screw (5) is a straight shaft threaded on one end. The other end is squared to receive the traversing handwheel (1), which slips over the square shoulders, and is held there by a nut (9) and washer (10). Between the handwheel and the threaded portion a collar is formed on the shaft. The shaft is placed in the cross head through the shouldered end, and screws into the link. The shoulder on it bears against the shoulder on the cross head to prevent the screw going inward; and a large cap also called the cross head cap (2) is bored out to slip over the screw, and has a shoulder which catches against the shoulder on the screw. This cap prevents any outward motion of the screw. A check nut (3) is screwed over the cross head in front of the cap, which adjusts the pressure of the cap against the shoulder, and allows the wear to be taken up.

The action of the mechanism is as follows: When the handwheel is turned the shoulder on the actuating screw prevents any lateral motion of this screw, and as the cross head is pivoted solidly

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to the trail, the link is screwed off or on the screw, depending on the direction of turning. As the link moves it carries the carriage body with it, being fastened to the body by the link pin through the lugs on the body.

The nut on the cross head pivot should be kept screwed up properly and any lateral play adjusted by screwing up the check nut and the cross head cap.

To Remove the Elevating and Range Gear

To remove the elevating and range gear, remove first the firing gear connecting arm and fulcrum. Remove the connecting rod on the range arc, and lift the range arc out of its bracket. Remove the caps from both the upper and lower elevating gear carrying brackets, and also remove the protecting cap. Unscrew the nut from the top of the elevating screw and remove the cover and the lug which slips on the top.

Turn the range gear handwheel so that the gun is depressed until the screw screws out of the range gear nut.

Remove the range screw nut and bearing from the carrying bracket.

Remove the key from the bottom of the elevating screw and holding the screw steady with one hand, turn the elevating handwheel until the screw is out of the elevating screw nut.

Remove the nut and bearing and the elevating screw.

To replace the mechanism exactly the reverse process is gone through.

In replacing the bearings and screw nuts, care should be taken that the open face of the range elevating gear is put in the bracket first and that the solid face of the elevating gear is entered first.

In replacing the bearings and elevating nuts, care must be taken that the open side of the bearing is inserted first in the upper gear, and the closed side first in the lower gear (with the teeth of the elevating nuts at the top in both cases), so as to insure that the gun is always elevated by revolving the handwheels toward the rear, or depressed by revolving the handwheels toward the front.

To Remove the Traversing Gear

Remove the link nut pin and the cross head pivot nut. The entire gear can now be lifted from the carriage.

Remove the large cap and unscrew the actuating screws from the link nut. Both screw and nut can now be removed from the cross head.

The reverse process is gone through to replace the mechanism.

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The Breech Mechanism

The breech block (14) is of the interrupted screw type, tapered so that it is larger at the front end than at the rear. It has two threaded and two flattened sectors which engage with corresponding sectors formed in the breech ring. The rear of the block is slightly larger and cylindrical in shape, and is threaded so as to screw into the block carrier (18). The block is bored out through its axis to form a seat for the firing mechanism. The forward end of this hole is closed, except for a hole large enough for the firing

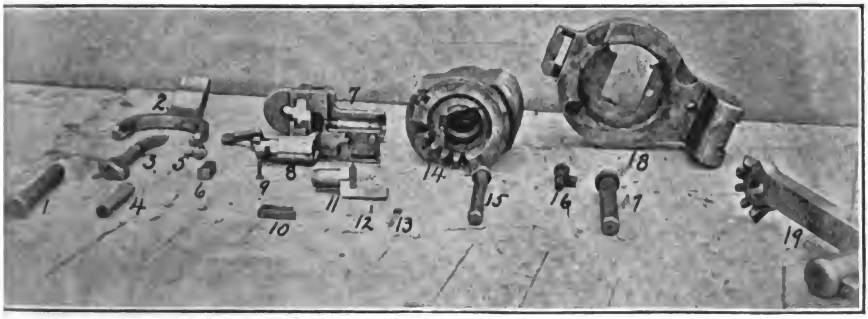

FIGURE 19. THE BREECH MECHANISM

1. Hand Lever Hinge Bolt.
2. Extractor.
3. Firing Lever.
4. Firing Spring.
5. Firing Pin.
6. Rebound Block.
7. Striker Guide Block.
8. Striker.
9. Securing Pin.
10. Tripping Piece.
11. Firing Spring Guide.
12. Tripping Piece Spring Screw.
13. Tripping Piece Spring.
14. Breech Block.
15. Extractor Hinge Pin.
16. Block Stop and Spring.
17. Carrier Hinge Bolt.
18. Block Carrier.
19. Hand Lever.

pin to project through, by the breech block bushing, which is screwed into place and held from turning by a screw in the top of the block. A hole through the block and channels in the carrier allow the escape of any gases from a ruptured primer.

The block carrier is hinged on the right side of the breech ring by the carrier hinge bolt (17), and is bored out and threaded to receive the threads on the rear end of the block. Two protecting lugs serve to hold the hinge bolt (1) of the breech mechanism hand lever. A block stop (16) with a spring on the face of the block carrier, which engages with a recess in the block, limits the rotation in the open position.

Hinged to the rear face of the carrier is the breech mechanism hand lever (19). This is provided with bevel teeth which engage with the bevel teeth on the rear end of the block and rotate it to the open or closed position as the lever is moved. The lever is held in the closed position by a catch which is pivoted in the lever, and

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engages with a recess on the lower side of the lower lug on which the lever is hinged.

The extractor (2) is made in one piece. On the inner end are two arms which project inward and clip over the rim of the cartridge case. The outer end is formed into a lug which the block carrier strikes as it is swung open. It is pivoted on a hinge pin (15) held on the right side of the breech ring, just in front of the block carrier hinge bolt.

Operation of the Breech Mechanism

When the hand lever is grasped tightly, the catch is released, and the lever is free to move. As the lever is pulled to the rear and right 120 degrees, the block is rotated, until at the end of the movement the threaded sectors of the block are opposite the flattened sectors of the breech recess, and the flattened sectors of the block are opposite the threaded sectors of the recess, the threads are all disengaged, and the block is free to be withdrawn from the breech recess. As the pull on the lever is continued the block carrier swings outward and to the right through 110 degrees, carrying the block with it. As the carrier leaves the face of the breech, the block stop springs into its recess in the block and holds it in the open position. The block carrier strikes the projecting lug on the extractor, throwing it forward. The extractor being pivoted on its hinge pin, the inner arms are thrown to the rear ejecting the empty cartridge case.

In closing the breech the lever is pushed to the left. The block being locked in the open position by the block stop, the carrier and block are swung into the closed position. As the block stop strikes the face of the breech it is pressed back out of the recess in the block, making the block again free to turn. The continued pressure on the lever rotates the block, engaging the threads, and securing it in position. As the lever swings into the final closed position, the lever latch engages in its recess and locks the block from turning.

The Firing Mechanism

The firing mechanism is of the continuous pull type, and is so arranged that the gun cannot be fired until the block is fully in place and the hand lever locked.

The mechanism consists of a striker (8) with a firing pin (5), a rebound block (6) with a securing pin (9), firing spring (4), a firing guide (11), a tripping piece (10), a striker guide block (7), and a firing lever (3).

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The firing pin is very short and slips into a groove on the forward end of the striker. The striker is cylindrical and is hollowed out to take the firing spring and the firing spring guide. It is closed at the forward end by the firing pin. A slot is cut in the striker just back of the firing pin in which the rebound block is placed, projecting out slightly on each side. A pin placed lengthwise in the striker and held in position by the firing pin acts as a guide for the rebound block in its slight movements back and forth in the striker. This is called the securing pin. The rear end of the striker has a projecting arm which holds the tripping piece and has also a slot in which a lug on the spring guide engages. The firing spring fits into the striker from the rear and bears against the rebound block. Over the firing spring and fitting inside the striker is the firing spring guide. This is a sleeve which fits over the spring and inside the striker, and is free to slide up and down in the striker as the spring is compressed. A flat head is formed on the sleeve which acts as the second point of compression contact for the spring and also as a bearing surface for the firing lever. An arm projecting to the rear on the guide carries a lug which fits into the slot in the arm of the striker and acts both as a guide for the striker and prevents the compression of the spring from forcing the guide out. The tripping piece is a flat piece of steel pivoted on a lug on the arm of the striker. It has a projecting point which engages with the firing lever, and is held in position by a flat spring called the tripping piece spring (13). The firing lever is a shaft about four inches long with a rounded lug at one end which bears against the firing spring guide on one side and the hand lever hinge bolt on the other. A projecting toe engages with the tripping piece. An arm on the other end extends out of the firing mechanism and the carrier, and when the breech is closed it engages with the trigger. Over the entire mechanism and fastened on to the block carrier is the striker guide block. This is held in place by the hand lever hinge bolt, and it in turn holds the firing mechanism in position. A slot is cut in the guide block to allow the striker to move backward and forward in its firing action. A knurled lever moves a cam which in one position engages a slot in the striker in such a fashion that the striker is held from moving. On the carrier are the words Safe and Fire opposite the two positions of the lever. In the safe position the firing mechanism cannot operate, but when turned to fire it operates freely.

Action of the Firing Mechanism

When the firing handle on the carriage is pulled, the trigger pushes against the arm of the firing lever. This turns the firing

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lever, and the cam on the opposite end pushes against the rear of the spring guide. The spring guide moves slightly forward and then the projecting flat head catches against a shoulder on the outside of the lever, bearing between the spring guide and the hand lever hinge pin, holding the spring guide forward. As the firing lever turns the projecting toe to the rear, the point being engaged with the tripping piece, the striker is drawn back also, compressing the firing spring. This movement continues until the projecting toe on the firing lever slips past the tripping piece. This frees the striker and the compression of the springs drives the striker forward. During this compression of the spring the rebound block is held tightly in the forward end of its slot in the striker. As the striker and rebound block move forward, and just before the firing pin protrudes from the forward end of the breech block, the rebound block strikes a shoulder on the inside of the breech block. The energy of the striker overcomes the remaining compression of the spring, however, and as the slot for the rebound block allows a slight movement of the block forward and back, the striker continues its forward movement, and drives the firing pin on its end against the primer of the projectile. As soon as the firing pin hits the primer and stops, the inertia of the striker is overcome. The spring being still under some compression, and pressing at the forward end against the rebound block, and at the rear against the spring guide, which in turn is engaged by means of a lug and slot, with the striker, the striker is forced to the rear until the rebound block again hits the forward end of its slot. The compression of the spring then holds it in place.

As the striker returns to position the flat spring on the tripping piece forces the tripping piece into reëngagement with the toe on the firing lever. The firing lever is returned to the normal position by the flattened shape of the notch in it, which fits around the hand lever hinge pin. The compression of the spring in forcing the spring guide back to its normal position forces the firing lever to turn back to the flattened part of its notch and the normal position.

To Remove a Wheel

To remove a wheel withdraw the split pin in the hub cap, and unscrew the cap from the wheel. Slip off the drag washer, and with a monkey wrench remove the nuts which hold the locking plate to the spokes.

Remove the locking plate and unscrew the octagonal nut. The box can now be forced by driving it with a block of wood and a

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sledge hammer. It will usually be necessary to loosen the nuts on the spoke bolts to relieve the pressure on the box, before it can be driven out.

To Remove the Hydraulic Buffer and Counter Recoil Springs (Gun in Battery)

Place the gun at depression and remove the outer nut. This will allow the cylinder to bear against the spring case cap.

Remove the filling plug. (It is not necessary to drain out the oil before removing the cylinder.)

Screw the spring compressor into the hole in the rear end of the control plunger, and take up the tension on the springs. A block and tackle may be used or the spring compressor attached to a caisson. Remove the split pin from the spring case cap and remove the piston rod nut. Unscrew the outer spring case cap. (Be careful that no one is in front of the gun after the cap is off until the springs are removed.)

Gradually release the spring compressor and screw off the inner nut as the cylinder passes into the spring case.

When the springs are fully extended, remove the spring compressor and remove the springs, bearing washers, parting plates, spring case, and buffer through the front end of the outer spring case. When removing the cylinder, be careful to keep the filling hole upright to prevent loss of oil.

Drain out the oil, and, holding the cylinder with a spanner on the stuffing box, unscrew the control plunger. Be careful not to scratch the plunger when withdrawing it from the cylinder head.

To remove the gland, pull the cotter pin from the spring stud, and press the stud back until it is disengaged from the notch on the gland. If it is then too tight to be turned by hand, a spanner on the stuffing box to hold the cylinder from turning and another on the gland will unscrew it.

To remove the stuffing box, elevate the gun as far as possible and holding the cylinder above the trail, cylinder head to the front place the cylinder head in the recoil lug so that the keys on the head engage in the slots in the lug. Place a block of wood or a box under the end of the cylinder, and with a spanner unscrew the stuffing box. Be sure that the spring stud is fully disengaged before attempting to force the stuffing box.

The piston rod and piston may now be removed.

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To Replace the Hydraulic Buffer and Springs

Slightly depress the gun. Replace the rear washer at the end of the outer spring case and insert three of the outer springs and parting plates in order.

Place the front washer (radius to the front) and one outer spring on the inner spring case. Place the rear washer (radius to the rear) and three inner springs with parting plates between, inside the inner spring case.

Place the front inner washer and the remaining spring on the cylinder and attach the spring compressor to the control plunger. Place the cylinder inside the inner spring case, care being taken that the filling plug is kept upright. The inner nut should be passed over the spring compressor before it is attached to the cylinder, and placed in position between the recoil lug and the buffer.

Replace the outer spring case cap and piston nut on the piston rod, first making sure that the stud securing box is in position and held by the split pin.

Compress the spring and draw the buffer into place. Care should be used that the keys on the cylinder head engage the slots on the recoil lug, and that the filling plug is upright. Screw the inner nut on the cylinder head as the buffer enters the recoil lug.

Screw on the outer spring case cap and secure it with the split pin. Remove the spring compressor and replace the outer nut, drawing it up tightly, and replace the filling plug.

IN REMOVING OR REPLACING THE GUN, IT MUST BE KEPT AT DEPRESSION OR SECURED FROM SLIDING OFF THE CRADLE.

Precautions to be Observed to Prevent Violent Recoils and Injury to the Carriage

See page 40, 75 mm. Handbook.

To Fill the Buffer

Place the gun at extreme depression and remove the filling plug. Fill the cylinder with a funnel until full. If possible allow the gun to stand for fifteen minutes to make sure that all the air is out of the cylinder and it is entirely full. Drain out about one tenth of a pint, and replace the filling plug. It takes about 4.5 pints to completely fill the cylinder. Always strain the oil and never allow dust to get into the inside of the buffer.

Alternative Liquids which may be used in an Emergency

See page 41, 75 mm. Handbook.

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1. Pure glycerine or a mixture of equal parts of glycerine and water.
2. Any heavy lubricating oil.
3. Soapy water or water containing a proportion of soda.
4. Clear water may be used in a great emergency only and should be drained out and the cylinder thoroughly dried after using.

Kerosene or any burning oil should never, under any consideration, be used in the buffer.

To Tighten the Packing (Gun in Position)

Remove the piston rod nut and outer spring case cap, and screw up the gland with the spanner provided for the purpose. The position of the gland must be such after tightening, that the retaining spring stud can enter the slot on it.

General Instructions

When the gun fails to recoil properly the cause is usually due to one of the following reasons:

1. Weaken or broken springs.
2. Dirt or want of lubrication on the gun guides of the cradle recesses.
3. Distortion of either the guides or the recesses.
4. Buffer gland screwed up too tightly.
5. Too much oil in the buffer.
6. Front flange of the inner spring case broken. (Gun will stay practically at full recoil if this happens.)

To Correct the above Troubles

The only way to correct broken or weak springs is to replace them. Weak springs may be detected by measuring them. The normal free length of the outer springs is 19.65 inches and the inner 18.58 inches. Any one spring, inner or outer, which is found with a permanent set of 1¼ inches or more less than its specified length, should be immediately discarded.

Keep the guides and recesses free from dirt at all times. There is no excuse for the gun failing to function properly due to this cause.

Distortion of the guides or the recesses cannot be remedied in the field, and necessitates returning the gun to the arsenal for repairs.

The buffer gland should never be screwed tighter than is necessary to prevent the loss of oil. It should be set up until the piston rod can be moved by hand only with a slight pull. The slot in the gland must be opposite the spring stud.

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If the buffer has been filled properly there should never be an excess of oil until the gun has fired enough to heat the oil considerably. If this happens and there is good evidence that such is the trouble, the oil can be drained out by unscrewing the control plunger and allowing enough oil to drain out so that the gun will return into battery. The oil should be saved and returned to the gun after the firing is over.

If the trouble is due to a broken spring case, special precautions should be taken as follows:

1. Place the gun at depression and run it back to about forty-three inches from the "in battery" position, the breech being supported on skidding.
2. Do not remove the piston rod nut.
3. Secure a rope to the breech lug on the gun and man it with four men to the rear. Tighten up on the rope and remove the pressure of the springs on the outer spring case cap. Unscrew the cap, keeping clear of the muzzle.
4. Ease up the pull on the check rope and allow the gun to run forward on the cradle and extend the outer springs.
5. Remove the piston rod nut, the cap, and the broken end of the spring case, and one outer spring.
6. Run the gun to the firing position and attach the spring compressor to the buffer and remove the cylinder and inner springs as instructed before. When the inner nut is removed the compression of the inner springs will have a tendency to force the gun to the rear about ten inches. This can be concentrated by attaching a light rope to the gun.

Miscellaneous

The Sights

Great care must be taken not to damage the sights when removing or replacing them. The parts of the carriage to which the sights are attached must be absolutely clean and free from burrs.

The Deflection Screw and Nut

These should be kept free from grit and dirt and should be well greased, and if removed for any purpose care should be taken in replacing that the spring in the nut (the latter being in halves) is properly compressed before entering the screw. The spring fitted in the deflection nut, to obviate backlash, may be found stronger than is necessary for its work, the result being stiffening and increased wear on the screw. The spring should require a weight of 5 to 7 pounds to compress it to 0.9 inch.

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The Adjusting Bushing

To be kept clean and well oiled, and if removed for any purpose steps should be taken to have the sight to the vertical plane of the gun.

The Meter Scale Ring

This should be kept clean and oiled, and if removed for any purpose on replacing it should be set to the horizontal plane of the gun and sight.

The Cap Squares

To remove cradle cap squares for cleaning, etc., the carriage body must be traversed as far as it will go to the left to admit the right cap square key being removed, and to the right to remove the left key.

To Remove the Outer Spring Case from the Cradle

1. Dismount the gun.
2. Carefully remove the buffer, consisting of the cylinder, piston rod, inner and outer springs, and inner spring case.
3. Remove the upper protectors (curved), rough foresight, upper handwheel pinion spindle of the elevating gear, and the indicator pinion spindle of the range gear.
4. Unscrew the spring case (by means of a rope and a handspike, or other suitable appliance). Care must be taken when the first portion of the thread of the spring case is disengaged from the cradle that the second portion of the thread is properly entered and not cross-threaded; also that the threads are clean and lubricated.

To Replace the Outer Spring Case

1. The converse of the above action takes place in reassembling the spring case and recoil cylinders.
2. Before mounting the gun the "Protector Slide" on the front end of the cradle should be removed to prevent the leather portion of the protector forcing out the metal and breaking off the screws when sliding the gun home.
3. After the gun is mounted, replace the "Protector Slide."

The Range Indicator

The yard and degree scale should be kept perfectly clean, free from grit, burrs, dents, and the revolving surfaces slightly greased.

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In replacing the eccentric bushing in the arc guides, care must be taken that the bushing is placed in such a position as to insure the least possible play between the teeth of the pinion and the elevating arc. The grooves in the eccentric bushing which engage the stop pin are arranged to give eight adjustments, which are numbered 1 to 8, Nos. 1 and 8 representing the minimum and maximum setting respectively.

Certain other bushings have the grooves numbered 1 to 8, but Nos. 1 and 5 indicate their minimum and maximum setting respectively.

To Remove the Indicator

Remove the rocking bar sight and disconnect the rod connecting the elevating screw at the arc joint; withdraw the arc until it is out of gear with the pinion, holding the spring case by the handle while doing so, gradually release the tension (by hand) on the spring by allowing the spring case to revolve slowly, so as to prevent the breaking of the spring, and remove the indicator from the spindle.

To Replace the Indicator

Remove the jamming plate, the two woodite washers, and the yard scale ring; place the spring barrel on the bearing on the cradle, and the spring case with the spring, on the spindle; turn the spring case by hand to the front until the spring is in full tension; release the spring case about a quarter of a turn, and engage the arc and connecting rod; replace the yard scale ring washers, jamming plate, and nut. Replace the rocking bar sight and adjust the yard scale ring to the horizontal plane of the gun.

The Brake Gear

When the brake is applied, the releasing lever must be pushed forward to a horizontal position.

Any wear in the eccentric can be adjusted by screwing up the connecting bolt of the link eccentric.

When assembling the "lever, releasing brake," the hexagon on the spindle portion of the lever must be placed in the eccentric so as to give the maximum amount of throw.

The Locking Shield Pawl Pin

It should be carefully noted that this pin is always in proper position when traveling.

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The 3-Inch Battery Wagon
(Model 1902)

With a few exceptions all parts of the battery wagon are interchangeable with corresponding parts of the caisson. The frame consists of two side rails fastened together at the front to form a seat for the lunette bracket, and projecting straight to the rear beyond the axle. The middle braces are fastened to lugs near the center on the axle, and to the side rails at the brake channel connection. The left lift handle on the trail is omitted in order that a forge vise may be attached, which remains in place when traveling. The prop is pivoted on a pin through the lunette bracket, and is "A" shaped to afford greater steadiness when unlimbered and when the vise is used. It is secured in traveling by means of one chain attached to the cross bar passing through a chain guide on the frame brace to a button on the lunette bracket.

The brake shoes, beams, boxes, guides, brake rods, cranks, and shaft bearings are interchangeable with those of the caisson. A special bearing attached to the axle holds one end of the brake shaft. The brake crank is secured upon the left end of the shaft, and is connected by means of a lever rod with the brake lever, and is attached to the right side of the battery wagon body on a diagonal side brace near its front end. A brake segment with ratchet teeth is also fastened to the wagon body.

The wagon body is of wood, and is attached to the side rails of the frame by four bolts and nuts. The interior of the body is divided into four compartments, and the largest of these can be entered from above at either end, the openings being covered by hinged lids. The other three are in the lower rear portion of the body, and are entered by a door at the rear end opening downward. The compartment on the right is for the saddler's chest, the one on the left is for the carpenter's chest, and the middle one is for cleaning material and a small stores chest. The door of these compartments is held in the closed position by a shot bolt at each corner, and a hasp hinged to the door at the center, secured over a staple riveted to the wagon body. The two top doors are hinged to the body near the center, and each is provided with a spring padlock. Two prop lids hold them in the open position. Two chains hold lower rear door in a horizontal position when open. The sides of the body and frame are braced securely, and are cross braced within by means of side strips, a vertical and horizontal tie rod, and two transverse braces in order to give sufficient strength for carrying two spare wheels. These are secured in upright position, one at each side,

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over the axle. The inner end of the wheel hub rests in the bronze spare-wheel support on top of the wagon body, and is secured by two spare-wheel fastenings attached to the sides.

Axle blocks between the chest bottom and axle give additional support under the spare wheels. A perforated foot rest is attached to the chest in front and held by brackets and tie rod. Two hand rail brackets with hand rails are riveted at each end of the front lid. Two grip straps are provided on the front of the chest, secured in the fasteners in the front of wagon body. The paulin straps are secured in fasteners on the front lid of the body. The top rear compartment is fitted with suitable frames and blocks, for carrying one grindstone, jack screws, and a chest for a spare breech mechanism. In rear of the axle under the body a frame is built for the purpose of carrying three large oil cans, each of capacity of five gallons. These cans are made of heavy sheet brass, and each is provided with a filling hole on top, with a special stopcock closed by a nozzle screw plug at the rear end. The chests in the rear compartments are wooden and iron bound at the corners. The carpenter's chest contains a complete assortment of carpenter's tools. The saddler's chest is a combined tool chest and stitching horse. A chest for spare sights is carried in each battery wagon, which contains one complete line of spare sights, including one breech bore sight and one muzzle bore sight.

For batteries equipped with steel poles, a spare pole is carried under the frame of the battery and store wagons.

The Store Wagon
(Model 1902)

The store wagon is similar in construction to the battery wagon. Handles are attached to the trail, as no vise is carried there, and the body forms a single compartment, with two doors on top. A crowbar is carried under chest, held to the frame by suitable fastenings and straps. The same arrangements are made for carrying spare wheel and oil cans, as on the battery wagon.

The Forge and Store Limber

The forge limber, model of 1902, is identical in construction with the other limbers, with the following exceptions: The chest has a door hinged to the front and opening from the top of the chest. The inside is divided into compartments. The center compartment carries a forge in front, and an anvil in rear, with tools on the walls of the compartment. The wood-lined compartment is for

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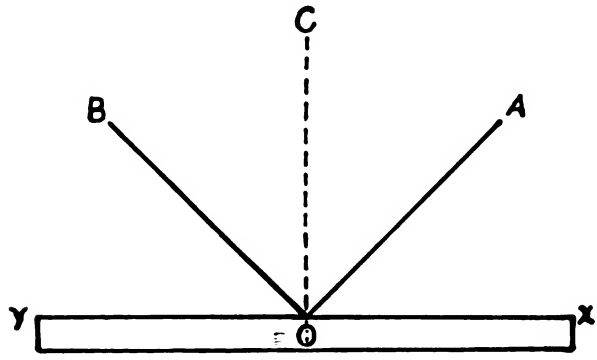
horseshoes. All the partitions are made of steel, flanged on the inner sides of the chest. The sledge hammer is carried on the foot-board, the handle in a bracket underneath the chest. Shot bolts riveted to each side of the chest fit in shot-bolt eyes riveted on the lids. The hasp on the center of the lid fits over a wing nut, which is riveted to the body of the chest, and a spring padlock for locking the limber door is attached to same. The store limber has a door on top of the chest similar to the forge limber. The inner part of the chest is divided into small compartments of a convenient size and shape to keep instruments of a battery. Tubular oil cans are suspended in bracket underneath outer end of the chest over the axle. (This also applies to the forge limbers.)

For contents of saddler's chest and carpenter's chest, together with a list of blacksmith's tools carried in the forge limber chest, see pages 198–199, 3-inch Handbook.

The Panoramic Sight

In teaching the nomenclature of the panoramic sight, model of 1904, the following parts should be covered: Rotating head, rotating head window, hood for azimuth circle, azimuth circle, worm



index, worm knob, eccentric lever, lug shank, rotating head prism, rotating prism, lower reflecting prism, field lens, eye lens, and objective lens.

Explain how the azimuth circle and the worm index are divided and related.

Show in what direction the rotating head points when the setting of the sight is zero, 1600, 3200, 4800, and 6400. Explain the use of the eccentric lever.

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The general principle and uses of lens and prisms should be explained to the candidates. Explain how the light rays are brought to a focus, at the focal point, by means of a convex lens. The objective lens is a lens of this type. The field lens magnifies the image while the eye lens reduces the pencil of light rays so that none are lost to the eye. When light passes from a rarer into a denser medium the rays are reflected off provided they approach the denser medium at certain angles. These angles vary from zero to X O A, limiting the angle, which varies for different substances.

That is if a ray of light approached the glass X Y at an angle less than the angle X O A or Y O B it would be reflected back into the air. If it approached the glass surface at an angle between O A and O B it would be refracted through the glass. In passing from a rarer to a denser medium, light is refracted towards the normal. In passing from a denser to a rarer medium, it is refracted away from the normal. The rotating head prism and the lower reflecting prism have a block surface against their rear so that the light will be reflected inside the glass. A prism shaped like the rotating head prism turns the rays through a right angle, thus inverting the rays. The rotating prism rectifies them again while the objective lens reverses them and brings them to a focus so that they can be magnified by the field lens. The lower reflecting prism inverts and reverses the rays so that the image appears in its normal position when viewed through the field and eye lenses. The slope of the lower reflecting prism should be explained here showing how a ray is inverted and reversed. The rotating head turns in order to view an object in any direction. In order to still have the object appear right side up there must be some change in the position of the rotating prism. The rotating prism is geared to the rotating head so that it turns one half as fast. In this manner the image always appears right side up. Show by the blue prints that this is true. The object of having the panoramic sight shaped in the way it is, is to afford a periscopic effect. Study pages 164 to 167, 3-inch Handbook.

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CHAPTER IV

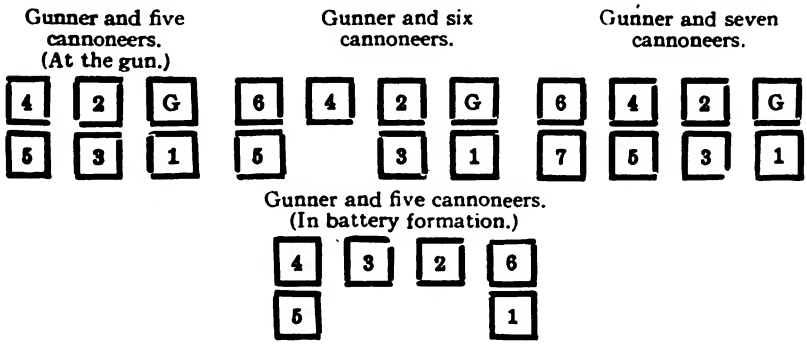
DRILL OF THE GUN SQUAD

AN important step in the development of the cannoneer is his schooling in the drill of the gun squad. This training can be given thoroughly in ten periods of an hour each. As it is presented below, it was tried out in the instruction of candidates of the F. A. C. O. T. S. The results obtained have proven its worth.

NOTE:—Paragraphs referred to in this chapter are in F. A. Drill and Service Regulations.

1st Hour. Paragraphs 135, 138, 170–177, 204.

The instructor in teaching the first hour will designate men to fill the positions in the gun squad, making it plain to each that he is gunner, No. 1, etc. Place each man in his proper position, beginning with the gunner, explaining that the squad's position is determined by that of the gunner's. After this has been done, cause the squad to fall out and then to fall in. Do this several times. DURING ALL EXERCISES THE FIRST TIME THEY ARE EXPLAINED, HAVE THE CANNONEERS STAND AT EASE AND MAKE THEM LOOK ABOUT SO THAT THEY WILL LEARN THE DUTIES AND POSTS OF ALL MEMBERS OF THE GUN SQUADS. Do not let the gunner raise his arm vertically to mark his position. Do not try to have the gun squads fall in at their proper posts at first; any convenient place will do until the "Posts of the Gun Squads" are explained. Caution all cannoneers that they must go straight to their proper posts without any confusion. Explain carefully how the cannoneers should cover off in a gun squad. The diagram shows below:



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Simply show this last formation once so that they will know how to cover off when the battery forms. The other three formations will be used in drilling the gun squads. Instructors should insist that gunners repeat the command "Fall in" in unison **immediately** after the same command by the instructor.

In teaching to "Call off," first explain the difference between "Call off" and "Count off." Do **not** give "As Gun Squads call off." Then cause each member of the gun squad to call out his position in a sharp loud tone of voice as you point to him. Insist that they call off **smartly.** Caution the cannoneers that although they cover off as shown in the diagrams they call off in rotation.

In teaching the "Posts of the Gun Squads" have the gunner take his position first. If the command is "In front of your pieces (caissons) FALL IN," the gunner places himself about three and one half yards to the front of and one and one half yards to the right of the end of the pole. The first two or three times have the squads placed accurately and let each cannoneer look around to see his relative position. If the command is "In rear of your pieces (caissons) FALL IN," the gunner places himself two yards to the rear of and one and one half yards to the right of the muzzle of the piece or center of the caisson door. If the command is "On the right of your pieces, facing them, Fall in," the gunner places himself two yards to the right of and one and one half yards to the front of the axle of the piece, etc. The gun squad may be moved to its post as a unit also.

In leaving the park the squads can be closed after the commands "Squads right, MARCH" or "RIGHT FACE" have been given. The squads, after closing, should be halted at the gunner's command —it makes a better movement. After the second hour squads should be posted properly **every day** when marched to the carriages (178–179) and should leave the park as prescribed (204).

2d Hour. Paragraphs 178–190. (F. A. D. & S. Reg.)

In teaching "To post the Gun Squads" explain that no command of execution is given for those maneuvers. On approaching the park, the instructor commands "Squads in front of your pieces (caissons)." At that command the gunner takes command of his squad and marches it to the designated position. The instructor should be very careful to march the squads to the park with the left in front when approaching from the right and with the right in front when approaching from the left.

In explaining the "Posts of the Cannoneers, carriages limbered," repeat verbatim the paragraphs from D. and S. R. F. A. It is the

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simplest way of explaining the positions of the different cannoneers. Each cannoneer should have his back on a line with the rear end of the wheel which he is opposite. Place the cannoneers separately at their posts to fix the different positions in their minds and let them look around. Then have the drill at attention requiring them to call off. In order to assist the instructor each cannoneer may be required to raise his right arm vertically as he calls off, this to be done only once in a while.

In teaching to post the cannoneers at the carriages limbered, instructors should insist that the gunners give the command "Posts" **immediately** after the instructor's command. If the gun squads are formed in front of the pieces and the carriages are in the formation "battery in line" and the command "Cannoneers posts" is given the gunner and all even numbered cannoneers should **run** down the right side of the carriages, the odd numbers down the left. If the squads are formed in rear of the pieces and the above command is given the gunner Nos. 1, 2, 5, 6, and 7 should run straight to their posts. No. 3 should go around the right of No. 4 who should stand in place until No. 3 has passed. Then No. 4 runs to his post.

In teaching to change posts, the movement should be executed individually by each candidate, then by all the cannoneers at a walk, **and finally at a run.**

If the cannoneers are formed in a gun squad and the command "Change posts, MARCH" is given, No. 2 and No. 4 step straight to the rear to the position of No. 3 and No. 5 respectively. No. 1 and No. 3 step off to the left oblique and take the places vacated by No. 2 and No. 4, respectively. No. 5 takes one short step to the rear, and jumps to the right and steps up into the position vacated by No. 1. In order to change the gunner and higher numbered cannoneers, the command "Gunners and all cannoneers change posts, MARCH," should be given. If the cannoneers are posted as a gun squad, when the above command is given, the gunner and all cannoneers except the highest numbered one (if he is in the front rank) step straight to the rear and occupy the positions as follows: Gunner steps into No. 1's; No. 2 into No. 3's; No. 4 into No. 5's; No. 6 into No. 7's. The cannoneers in the rear rank all oblique to the left and take their positions as follows: No. 1 steps into No. 2's; No. 3 into No. 4's; No. 5 into No. 6's. If the highest numbered cannoneer is in the rear rank he runs around the rear of the squad and occupies the position vacated by the gunner. If the highest numbered one is in the front rank he jumps across the front of the squad into the gunner's position. If the cannoneers have been posted at the carriages limbered, and the command "Change

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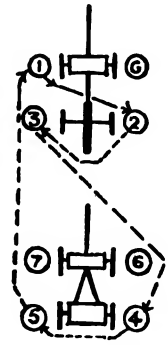
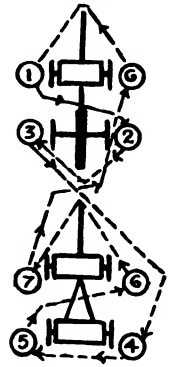
posts, MARCH," is given, cannoneers change as shown in the diagram below.



If the command "Gunners and all cannoneers change posts, MARCH," is given gunner and cannoneers change as shown below:



The commands "Change posts, MARCH" and "Gunners and all cannoneers change posts, MARCH," should be used as an exercise to make the candidates think quickly as well as for drill purposes. Consequently they should be interchanged quite often.

Always make the cannoneers execute the commands as prescribed above. After either of the above commands has been given, have the cannoneers call off so as to fix their new numbers in their minds. **The cannoneers should change posts quite frequently in order to give each a chance to become familiar with each position. This is the secret of obtaining well-instructed gun squads.** In all movements the cannoneers should be cautioned that at no time is it necessary to bump into one another and otherwise cause confusion.

3d Hour. Paragraphs 183–187.

From now on, half of the drill should be with the caisson model of 1902 and the other half with caisson model of 1916. In teaching,

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"To mount the cannoneers" during the first two or three attempts, cause the cannoneers to face toward the wheels opposite which they are posted, while explaining the movement. Demonstrate with two men and correct them. This avoids keeping all men in the positions of "Prepare to mount," while explanations and corrections are being made. No. 2 in mounting turns to the right about; No. 3 to the left about; No. 4 to the left about and No. 5 to the right about on the 1902 model caisson; No. 4 to the left about and No. 5 to the right about on the 1916 model caisson. In mounting the caisson model of 1916, Nos. 4 and 5, place the foot farthest from the wheels at the junction of the footboard and the trail, and grasp hands. Cannoneers mounting on the limbers should be made to place the foot farthest from the wheels on the chest and step down. Do not let the men hurdle the chests. Cannoneers after mounting will be required to fold their arms, holding them so that the entire arm is horizontal. Do not let them cross their legs. Instructors should see that the poles are held down by extra cannoneers while the other cannoneers are mounting and dismounting.

In dismounting, at the command "Prepare to dismount," all the cannoneers except the two on the axle seats of the gun stand up. Cannoneers on the axle seats simply unfold their arms—nothing more. At the command "Dismount," cannoneers jump to the right and left oblique clear of the wheels and take their posts on the run. Cannoneers should not dismount while the carriages are moving.

4th Hour. Paragraphs 191–195.

The instructor should explain the post of each cannoneer and have him go there first at a walk, later on a run. After all have reached their posts, have them call off and let them all look around. Explain that the posts of the cannoneers are the same whether the piece is moved or the caisson, No. 4 and No. 5 simply transferring to the bodies of the carriages to be moved and No. 6 and No. 7 going behind the body of the carriage if the movement is to the front, and in front, if the movement is to the rear, even numbers on the right and odd numbers on the left. The gunner and No. 1 should be at the end of the pole and should grasp it with both hands. Nos. 2, 3, 4, and 5 should grasp the spokes of the wheel with both hands spread well apart. The instructor should explain that the pole determines the front when the carriages are limbered. Considerable difficulty will be had at first in making the cannoneers start to their posts when the command "Pieces (caissons) forward (backward)" is given. At first the cannoneers will hesitate and

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then run to their posts. To overcome this, repeat the movement several times, warning them each time what command will be given next. Then after they become proficient, omit the warning. At first the carriages should be actually moved a short distance by the cannoneers. Later the command "March" can be followed immediately by the command "Halt" so that the carriage will not be moved at all. Insist that at the command "Halt," all cannoneers move **immediately** to their posts. They will hesitate at first. After this when it is necessary that a carriage be moved, insist that the cannoneers take their proper posts each time and carry out the movement as prescribed.

The instructor should have the carriages moved into "double-section" formation, the caisson first being on the right and then on the left of the piece, before explaining the disposition of the carriages before unlimbering. Impress upon the cannoneers' minds that the caissons should habitually be on the left of the piece after unlimbering so that the gun can be loaded more readily. Show them how the breech block being open would interfere with the loading. Explain that in case of absolute necessity the caisson might be put on the right of the piece after unlimbering but should be moved to the left as soon as possible. Explain the fact that the carriages being two yards apart before unlimbering allows just enough room for either the piece or the caisson to be turned around on its inside wheel, thus putting it in its exact place after unlimbering—with one foot between wheels (caisson model of 1902).

From now on always begin and end the hour's instruction with a short **snappy** review of a few movements already covered in the drill of the gun squad. This wakes the cannoneers up.

5th Hour. Paragraphs 188, 196–199.

The instructor should explain in detail that when fire is to be delivered to the front, the caisson establishes the position (caisson model of 1902) because the trail already points in the proper direction. When fire is to be delivered to the rear, the piece establishes the position. With the caisson model of 1916 in firing to the front, neither carriage establishes the position as both have to be turned around, but the piece should always be put into position to fire first if possible. In unlimbering to fire to the flank the element (gun or caisson) on the side toward which fire is to be delivered establishes the position. If possible the piece is usually put in on this side so that it will get into action first.

In teaching "Action front" it will be best to proceed as follows: First using the caisson model of 1902, have the carriages placed in

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double section, caisson on the left. Use one squad to demonstrate it the first time. Mount the cannoneers and give them "At Ease." Then as the instructor describes the duty of each cannoneer, each as his duty is explained dismounts and performs it. The first time describe only the duties as far as the gunner and No. 4 raising their arms vertically as a signal for the drivers to drive on. Do not have the limbers moved off. Explain that the gunner in dismounting pivots on his right arm so that he lights on the ground faced in the direction he is to move, *i. e.*, toward the trail of the piece. No. 1 pivots on his left arm. The gunner grasps the float handle with his right hand, unlatches the pintle with his left, and raises it vertically. Nc 1 grasps the float handle with both hands. No. 2 runs around the muzzle of the piece to the wheel which will be the right when the piece is in action. No. 3 runs around the muzzle to the one which will be the left. After this has been explained start on the caisson. No. 4 dismounts, jumping to the front so that he lands on the ground near the trail handle. He grasps this with his left hand, unlatches the pintle with his right, and raises his right arm vertically. No. 5 grasps the trail handle with both hands. No. 6 goes to the wheel of the caisson which is now the right and No. 7 to the one which is now the left.

Now have the pintles locked and the cannoneers mounted again. Assign two extra cannoneers to the pole of each limber to draw them away when necessary. At the command "Action front" have the cannoneers perform all the duties just explained and have the limbers moved about three feet and the poles dropped. Then explain that the caisson trail is dropped, No. 4 setting the brake. Have the cannoneers stand fast after placing the carriages in position. Have the piece placed in position by having the gunner and No. 1 move the trail of the piece away from the caisson, pivoting the piece on the wheel which No. 2 is working on. Explain that the piece, at the command of the **gunner,** should be run up so that there is an interval of one foot between the adjacent wheels of the piece and caisson and so that the piece is about ten inches in advance of the caisson.

Now explain the reasons for the positions of the carriages unlimbered. First: That the interval of one foot is used to allow for slight movements of the trail and at the same time afford as much protection as possible to the gun squad. Second: That the piece is ten inches in advance of the caisson to allow for that much recoil before the spade buries itself in ordinary ground.

Now explain the posts of the cannoneers, carriages unlimbered but not prepared for action. Cannoneers should **always** dress to

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the **right.** Explain how the limbers move off and have all cannoneers watch. In going into action the instructor should insist that the limbers be moved away as prescribed. After going through "Action front" in detail, have all the gun squads execute it as rapidly as possible. This should take up about forty minutes of the period. The last twenty minutes should be devoted to explaining and executing "Action front" with the caisson model of 1916. The cannoneers at the piece perform the same duties as with the 1902 model caisson. Nos. 4, 5, 6, and 7 turn the caisson about, trail away from the piece, pivoting on the wheel which No. 7 is working at. After the caisson has been turned, it is run up to its proper position with respect to the piece **under the direction** of No. 4. After the caisson has been properly placed No. 4 lets down the prop and No. 5 sets the brake. The posts of the cannoneers, carriages limbered but not prepared for action (caisson model of 1916) are modified as follows: No. 4's post is two feet in rear of the caisson, on the right side of the trail and about one foot from it; No. 5's position is two feet in rear of the caisson, on the left of the trail, and about one foot from it; No. 3's post is two feet in rear of No. 4 and covering him.

6th Hour. Paragraph 202.

Review "Action front," first with the caisson model of 1902. Explain in detail the posts of the cannoneers for limbering. **Insist that the cannoneers stand well back against the wheels until the limber is halted** in position. This does not mean that as soon as the gunner and No. 4 give the command "Limber halt" that the cannoneers step out. It means that after the limber has swung around to its proper position and **halted,** the cannoneers limber up the carriages. The drill regulations prescribe exactly what each cannoneer should do. The limbers should be brought up as shown in the diagram below. Gunner and No. 4 give the command "Limber halt" when the axle of the piece limber and caisson limber respectively have arrived opposite the lunette. The cannoneers pulling the limbers should turn the limbers quickly so that they will pivot in place.

The last half hour should be spent in explaining and executing "Limber front and rear" with the caisson model of 1916. In each squad the gunner, No. 1, No. 2, and No. 3 perform the same duties as with the caisson model of 1902. No. 5 releases the brake before leaving his post. Nos. 4 and 5 hasten to the trail of the caisson and No. 4 raises the caisson prop. No. 6 hastens to the wheel of the caisson that is to become the right wheel of the caisson limbered.

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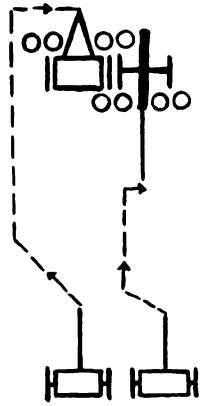
No. 7 hastens to the one which is to become the left. The caisson is rotated 180 degrees, trail away from the piece, the caisson pivoting on the wheel which No. 7 is working at. This is done under the



direction of No. 4. The trail is dropped and all cannoneers take their posts for limbering. Limbers are brought up and carriages limbered as prescribed for the caisson model of 1902.

7th Hour. Paragraph 937.

Part of the hour should be devoted to a practical review of the work covered during the previous week. After the carriages have been unlimbered and placed in their proper positions the instructor should explain "To move by hand the carriages unlimbered." First explain that the direction in which the muzzle of the piece points, carriages unlimbered, determines the front. At the preliminary command "Pieces forward (backward)," the gunner grasps the left trail handle with both hands, No. 2 the right trail handle. Nos. 1 and 6 go to the right wheel, No. 1 grasping the spokes of the front half of the wheel with both hands, No. 6 grasping the spokes of the rear half of the wheel in the same manner. Nos. 3 and 7 go to the left wheel of the piece. No. 3 working at the front half of the left wheel and No. 7 working at the rear half. No. 4 goes to the rear of the piece on the right of the trail (muzzle), No. 5 to the rear (front) of the piece on the left side of the trail (muzzle), both assisting by pushing against the breech of the gun (axle seat). The gunner and No. 2 lift the trail **at the preliminary command.** At the command "Caissons forward" explain to the candidates that all cannoneers go to the same posts at the caisson as at the piece with the exception of the gunner, Nos. 2, 4, and 5. When moving the caisson (model of 1902) at the command "Caissons forward (backward)," No. 4 runs around the left of the caisson, jumps the trail, and

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releases the brake. He then takes his post, grasping the right trail handle with both hands, No. 5 runs around the left of the caisson and grasps the left trail handle with both hands. As soon as No. 4 has taken his post both cannoneers lift the trail. Nos 1 and 6 work at the right wheel of the caisson in the same places as at the piece, Nos. 3 and 7 at the left wheel. The gunner and No. 2 push against the rear (front) of the caisson, the gunner on the right. After the command "Halt," No. 4 sets the brake before taking his post.

Part of the hour should be spent in explaining and executing "Caissons forward (backward)" with the caisson (model of 1916). At the preliminary command "Caissons forward," No. 5 releases the brake and goes to the left trail handle grasping it with both hands. No. 4 goes to the right trail handle and raises the prop. Other cannoneers go to the same posts as at the caisson (model of 1902). At the command "Halt," No. 4 lets down the prop and No. 5 sets the brake after going to his post. Explain that the caisson (model of 1916) at the command "Caissons forward" is moved in the direction of the muzzle of the piece and is not turned around.

8th Hour. Paragraph 200.

In explaining "Action rear," use the same method as in explaining "Action front." Have the caisson (model of 1902) placed on the right of the piece and mount the cannoneers. As the instructor describes each duty, the particular cannoneer referred to dismounts and performs that duty. The posts for unlimbering are the same as in "Action front." After the carriages have been unlimbered the trail of the piece is dropped in place. The caisson is turned around 180 degrees, trail away from the piece, pivoting on the wheel which No. 7 is working at. This should place the caisson in its exact position. If it is not, No. 4 gives the proper directions to have it placed there. After it has been turned and placed in its proper position, the trail is dropped. No. 4 sets the brake and all cannoneers take their posts at the carriages unlimbered. The last half hour should be devoted to explaining and executing "Action rear" with the caisson model of 1916. The caisson after being unlimbered is moved to its proper position under the direction of No. 4. In getting the caisson into position, the cannoneers should wheel the carriage sharply to the right, moving toward the piece, then wheel it to the left so as to place the caisson one foot from the piece and ten inches to the rear. After the caisson has been placed in its proper position, No. 4 lets down the prop and No. 5 sets the brake after reaching his post. The limbers move off as prescribed in the drill regulations. **Insist that they be taken off that way.**

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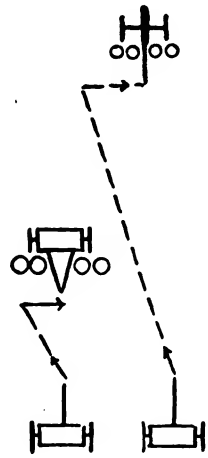
9th Hour. Paragraph 203.

Starting with the caisson (model of 1902) explain in detail "Limber rear." All cannoneers go to the caisson. They take the same positions as they do at the command "Caissons forward." The caisson is turned around 180 degrees, trail away from the piece, pivoting on the wheel which Nos. 3 and 7 are working at. After the carriage has been turned around, it is run twenty yards straight to the rear. The trail is dropped and all cannoneers run to their posts for limbering. Part of the hour should be devoted to explaining and executing "Limber rear" with the caisson (model of 1916). The caisson is not turned around. The cannoneers at the command "Limber rear" take the same posts as they do when the command "Caissons backward" is given. No. 5 releases the brake before leaving his post, No. 4 lifts the prop, and the carriage is run twenty yards straight to the rear. The trail is dropped and all cannoneers run to their posts for limbering. Limbers should not start to move out until the caisson has been moved to its new position. Limbers move out as shown in the diagram below and the carriages are limbered up as in "Limber front and rear." As soon as the cannoneers have limbered the carriages, they take their posts at attention.



10th Hour. Paragraph 201.

First explain "Action right (left)" using the caisson (model of 1902). Have the piece put on the right (left) of the caisson. Follow the same method in explaining the above as was used for "Action front" and "Action rear." The positions of the cannoneers for unlimbering are the same as before. After the carriages have been

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unlimbered the piece is turned through 90 degrees, the trail moving away from the direction of fire, the piece pivoting on the wheel at which No. 3 is working. After the gun is in position the trail is dropped. The caisson is turned through 90 degrees, trail moving toward the direction of fire, the caisson pivoting on the wheel which No. 6 is working at. After the caisson is turned it is moved up to its proper place on the left of the piece, the trail is dropped, No. 4 sets the brake, and the cannoneers take their posts. Now explain and have executed "Action right (left)" with the caisson on the side toward the direction of fire. In this case, as soon as the carriages have been unlimbered the caisson is turned through 90 degrees, pivoting on the wheel at which No. 6 is working, trail moving toward the direction of fire. As soon as the caisson has been turned the trail is dropped and No. 4 sets the brake. The piece is turned through 90 degrees, trail away from the direction of fire, the piece pivoting on the wheel at which No. 3 is working. After the piece has been turned, it is run up to its proper place under the direction of the gunner and the trail dropped. All cannoneers take their posts.

The last half hour should be spent in explaining and executing "Action right (left)," using the caisson model of 1916, the piece being on the right (left) of the caisson. As soon as the carriages are unlimbered the piece is turned as before (caisson model of 1902) the piece being on right (left). The caisson is turned through an angle of 90 degrees, trail away from the direction of fire, the caisson pivoting on the wheel at which No. 7 is working. After the caisson is turned it is placed in position under the direction of No. 4. No. 4 then lets down the prop and No. 5 sets the brake. If the caisson is on the flank toward which fire is to be directed, after the carriages have been unlimbered the caisson is turned through 90 degrees, trail away from the direction of fire, caisson pivoting on the wheel at which No. 7 is working. After the caisson has been placed in its proper position, No. 4 lets down the prop and No. 5 sets the brake. The piece is pivoted on the wheel at which No. 3 is working and then is placed in position under the direction of the gunner.

The instructor should have a written review of all the work covered during the ten hours.

This completes the course in gun squad drill. Every day during drill of the firing battery a few movements of drill of the gun should be reviewed. If the firing battery drill becomes slow at any time, a few movements of drill of the gun squad will wake the cannoneers up.

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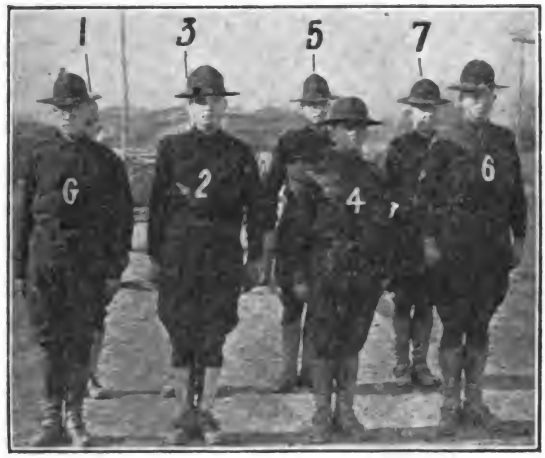
Illustrations of Gun Squad Drill

The purpose of this series of pictures is to present the drill at the guns in an accurate and clear way so that anyone studying fire discipline or gun squad drill can by using these photographs with the drill regulations easily gain a thorough knowledge of the duties of the cannoneer.

THE GUN SQUAD

Consists of the gunner and seven cannoneers; gunner and even numbers in the front rank, odd numbers in the rear rank, forty inches between ranks. The gunner establishes the position without raising his hand, so that the center of the rear rank is two yards from and immediately in front of the pole. D. & S. R. F. A., 138 and 175.



TO POST THE GUN SQUADS

As the squads arrive near the carriages, the instructor commands: SQUADS IN FRONT (REAR) OF YOUR PIECES (CAISSONS). Each gunner then marches his squad to its carriage and posts it in the indicated position. The squad is shown posted in the rear of its piece. D. & S. R. F. A., 176 and 178.

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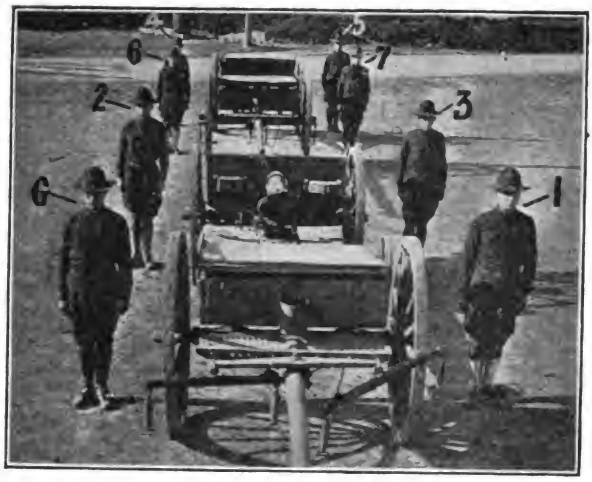

TO POST THE CANNONEERS

At the command (1) CANNONEERS, (2) POSTS, each gunner repeats the command "POSTS," the cannoneers double time to the positions illustrated standing at attention, two feet outside the wheels, their backs on line with the rear of the tire. D. & S. R. F. A., 180 and 181.

"CANNONEERS; PREPARE TO MOUNT"
(1916 caisson)

Nos. 4 and 5 grasp the chest handles with the hand nearest the wheel, place the foot farthest from the wheel at the junction of the trail and footboard, and clasp hands. In mounting, No. 4 turns to the left about, No. 5 to the right about.

"CANNONEERS; PREPARE TO MOUNT"
(1902 caisson)

Nos. 4 and 5 grasp the chest handles nearest the wheel and place the foot nearest the wheel on the step. They do not clasp hands. D. & S. R. F. A., 184.

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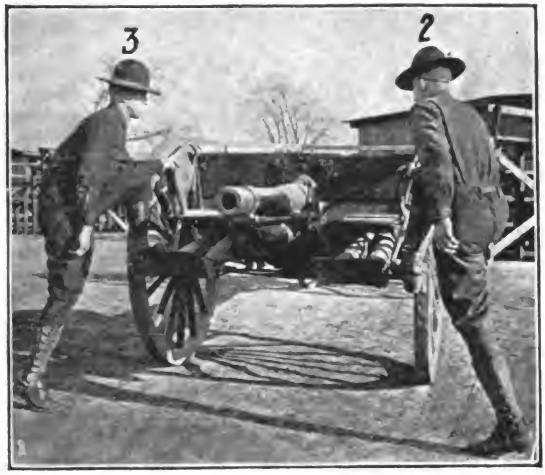

"CANNONEERS; PREPARE TO MOUNT"

Nos. 2 and 3 place the foot nearest the wheel on the brake beam and grasp the seat arm. In mounting, No. 2 turns to the right about, No. 3 to the left about. D. & S. R. F. A., 184.

"MOUNT"

The cannoneers who mount on the limber chests place the foot farthest from the wheel on the top of the chests and step down on the footboard. They must never be allowed to hurdle the chests. D. &. S. R. F. A., 184.

"MOUNT"

At this command, all cannoneers spring up and seat themselves as illustrated. All unnecessary movements must be eliminated. D.& S. R. F. A., 184.

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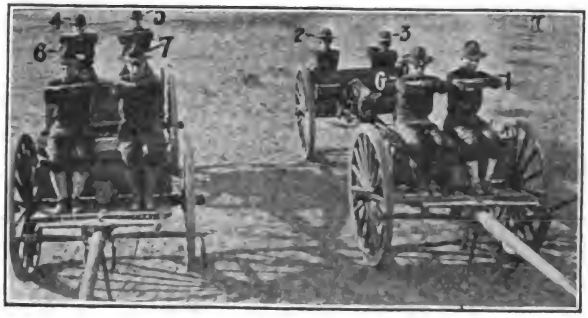
"CANNONEERS; PREPARE TO DISMOUNT"

At this command, the cannoneers on the chests rise and stand at attention. Those on the axle seat unfold their arms. At the command "DISMOUNT," all jump to the ground and take their posts at the double time. D. & S. R. F. A., 186.

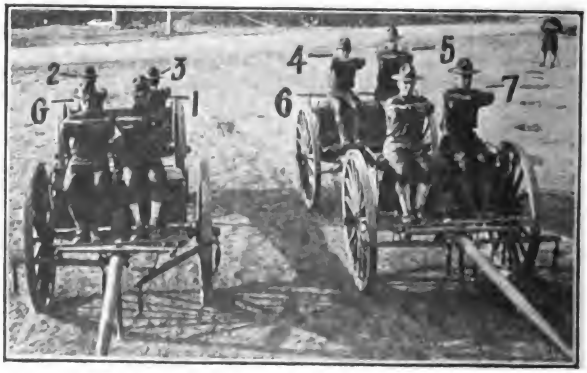


"DOUBLE SECTION RIGHT OBLIQUE"

This illustrates the disposition of the carriages before the command "ACTION REAR." Learn the six general rules (198). D. & S. R. F. A., 193 and 194.

"DOUBLE SECTION LEFT OBLIQUE"

If it is intended to fire to the front, the caisson should be on the left of the piece before unlimbering. D. & S. R. F. A., 194.



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TO MOVE BY HAND THE CARRIAGES LIMBERED

1. PIECE FORWARD. At this command the cannoneers double time to the indicated positions. 2. MARCH. The carriage is moved in the direction in which the pole points. 3. HALT. The carriage is stopped, the pole lowered to the ground, and the cannoneers double time back to their posts. D. & S. R. F. A., 191.

THE GUNNER UNLATCHING THE PINTLE OF THE PIECE

The gunner grasps the trail handle with his right hand and unlatches the pintle with his left. Notice how No. 1 stands ready to assist the gunner.

"ACTION FRONT"
(The piece)

The gunner and No. 1 jump to the trail handles, Nos. 2 and 3 run around the muzzle to the wheels farthest from their axle seats. The gunner unlatches the pintle and assisted by No. 1 raises the lunette; then by raising his left arm he signals the drivers to drive on. D. & S. R. F. A., 199.

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"ACTION FRONT"
(The caisson)

No. 4 unlatches the pintle with his right hand and assisted by No. 5 raises the trail, raising his right hand as the signal for the limbers to drive on. D. & S. R. F. A., 199.

POSTS OF THE CANNONEERS, CARRIAGES UNLIMBERED BUT NOT PREPARED FOR ACTION

(1916 caisson)

Note the positions of Nos. 3, 4, and 5 at the caisson.

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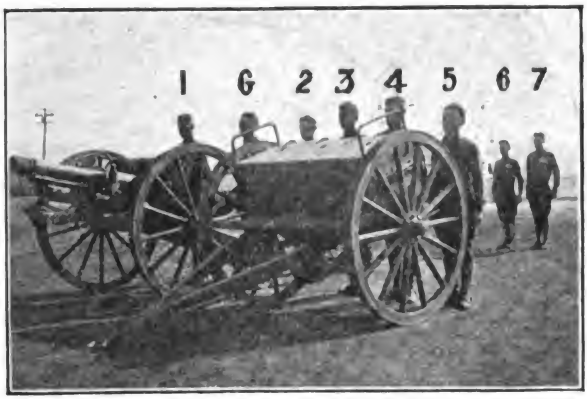
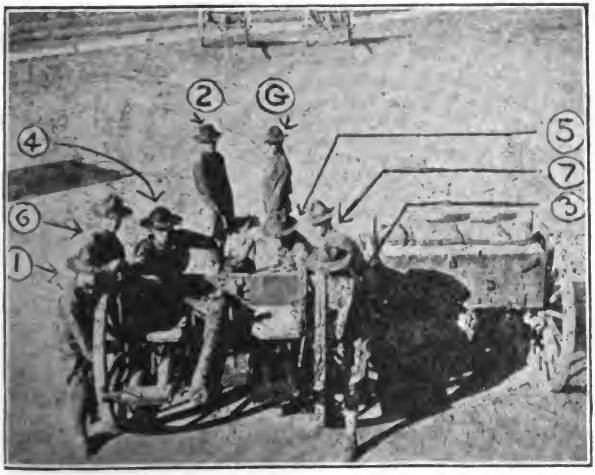
POSTS OF THE CANNONEERS, CARRIAGES UNLIMBERED BUT NOT PREPARED FOR ACTION

(1902 caisson)

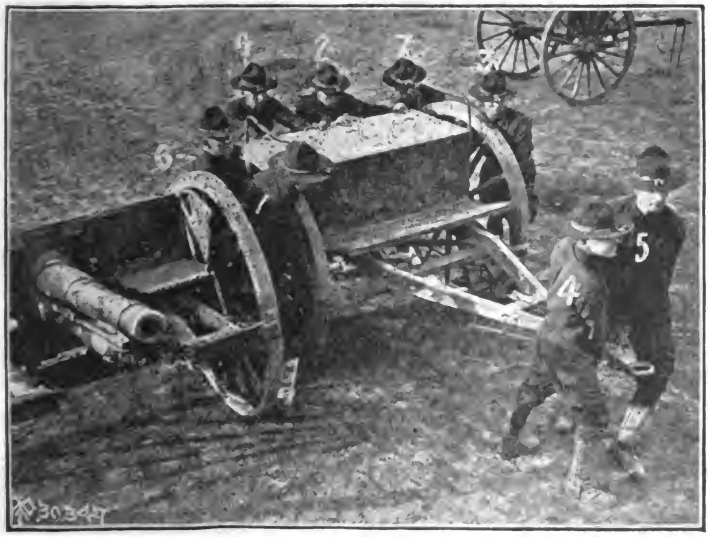
This front view illustrates exactly paragraph 188, D. & S. R. F. A.





"PIECE FORWARD"

The front of the piece unlimbered is the direction in which the muzzle points. Hands grasping the spokes should be well apart. D. & S. R. F. A., 937.



"CAISSON FORWARD"

(1902 caisson unlimbered)

Illustrating paragraph 937, D. &. S. R. F. A.

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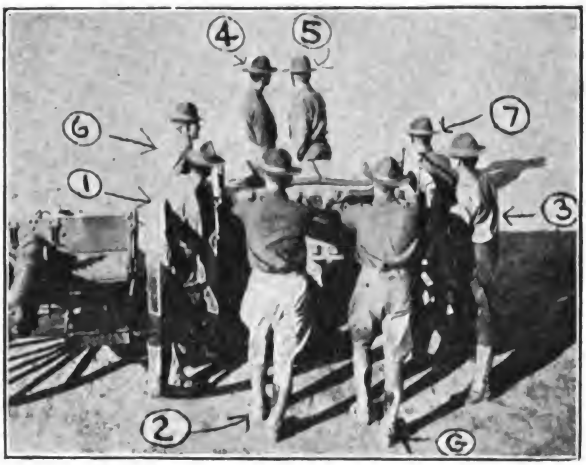

"CAISSON BACKWARD"
(1916 caisson unlimbered)

The trail of the 1916 caisson unlimbered always points to the rear, the 1902 caisson to the front.

"LIMBER FRONT AND REAR"

The cannoneers are shown in their positions prior to bringing up their limbers. D. & S. R. F. A., 202.

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Questionnaire for the Course in Gun Squad Drill

The ten sets of questions which follow are arranged progressively with the purpose of enabling the cannoneer to pick out definitely the more important parts of the daily assignment. Answers are not given as it is the desire to let the cannoneers obtain the proper information from the Drill Regulations and the Matériel Handbook.

First Set

Assignment for study: D. & S. R. F. A., 135, 138, 170–173, 174, 175–177, 204:

1. Of what does a gun squad consist?
2. How should a gunner take his seat, carriages unlimbered and prepared for action?
3. Draw a diagram of a gun squad indicating intervals and distances.
4. When the command "Fall in" is given what does the gunner do?
5. Give three commands which indicate three different places of formation.
6. What command does the gunner give after the commands (1) Squads Right, (2) March, (3) Close, (4) March?
7. How does a gun squad call off?
8. Explain how a caisson squad calls off.
9. Explain the position of the squad at the following formations:
   (a) In front of the piece.
   (b) In the rear of the caisson.
   (c) When no special place of formation is designated.
10. Explain two ways in which the gun squad may leave the gun park.

Second Set.

Assignment for study: D. & S. R. F. A., 178-179, 180-182, 189-190:

1. The gun squads are in column and approaching the carriages, what command is given to post the squads in their proper positions and what does the gunner of each squad do?
2. (a) When do you approach the park from the right?
   (b) When do you approach from the left?
3. What are the posts of the cannoneers, carriages limbered?
4. What command is given to post the cannoneers?
5. When the command to post the cannoneers is given, what do the cannoneers and gunners do?

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6. Draw a diagram showing the posts of the cannoneers, carriages limbered, indicating distances.

7. Draw a diagram showing posts of the cannoneers, carriages unlimbered but not prepared for action.

8. The command "Change posts, March" is given. What cannoneer takes the place of gunner? No. 1?

9. In question No. 8 is your answer applicable with carriages unlimbered?

10. When do higher numbered cannoneers change posts?

Third Set.

Assignment for study: D. & S. R. F. A., 183–185, 186–187:

1. Where does No. 3 mount, carriages limbered?

2. Where do Nos. 8 and 9 mount, carriages limbered?

3. From which direction do cannoneers on the caisson mount?

4. (a) Using the 1902 model limber, where is the right foot of No. 6, when prepared to mount?

(b) No. 7?

5. The command "Mount" is given. Explain how the cannoneers who mount on limber chests take their positions.

6. With which hand does No. 2 grasp the seat handle when prepared to mount?

7. At the preparatory command to dismount, what do the cannoneers do?

8. At the command "Dismount," what do the cannoneers do?

9. From which side do the gunner and even numbers mount?

10. Which hand of what numbered cannoneer does No. 5 grasp when mounting?

Fourth Set.

Assignment for study: D. & S. R. F. A., 191–192, 193–195:

1. (a) Carriages limbered; "Pieces Forward," where does No. 2 go? No. 5? No. 7? Gunner?

(b) At the command "Halt," where does No. 6 go? No. 4? No. 1?

2. What determines the front, carriages limbered?

3. Carriages limbered; give the proper commands for moving the piece forward. Backward.

4. What formation should the carriages be in before unlimbering?

5. If you wish to fire to the front, on which side of the piece should the caisson be? Why?

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6. What is the chief objection to having the caisson on the right of the piece while firing?

7. In moving the carriages limbered, what position should the cannoneers at the wheels take?

8. "Action Rear"—On which side of the piece should the caisson be before unlimbering? Why?

9. What determines the front, carriages unlimbered?

10. After unlimbering, what is the distance between adjacent wheels of the carriages?

Fifth Set.

Assignment for study: D. & S. R. F. A., 188, 196–197, 199:

1. Which carriage establishes the position in firing to the front? To the rear? To the flank?

2. When using the 1916 model caisson, which carriage should first be moved into position?

3. "Action Front"—What does the gunner do up to the time he signals the drivers to drive on?

4. "Action Front"—What does No. 2 do? Who sets the brake on the 1902 caisson? On which wheel is the piece pivoted?

5. Why is there an interval of only one foot between carriages unlimbered? Why is the piece placed ten inches in advance of the caisson?

6. What are the posts of the cannoneers, carriages unlimbered and prepared for action?

7. "Action Front"—Is the caisson always turned about?

8. Who has charge of the movements of the caisson?

9. "Action Front"—1916 model caisson—Describe what the cannoneers working on the caisson do.

10. "Action Front"—Describe the movements of the limbers. Which moves out first?

Sixth Set.

Assignment for study: D. & S. R. F. A., 202:

1. What is the position for the cannoneers for limbering? (Diagram.)

2. When do Nos. 4 and 5 jump to the trail handles?

3. Who gives the command "Limber, Halt"? When is the command given?

4. "Limber Front and Rear"—How do the limbers approach the gun position?

5. What is the first thing No. 5 does on 1916 model caisson at the command "Limber Front and Rear"?

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6. A 1916 model caisson is used at the command "Limber Front and Rear." What do the Nos. 4, 5, 6, and 7 do?

7. "Limber Front and Rear"—Limbers approaching from the right flank. Limbers of which section should lead? On which side should the piece limber be?

8. Draw a diagram showing the manner in which the limbers of a section approach their respective carriages at the command "Limber Front and Rear."

9. Who has charge of bringing the limbers up at the command "Limber Front and Rear?"

10. Why should the cannoneers at the trail handles wait until the limbers have been put in position before jumping to the trail?

Seventh Set.

Assignment for study: D. & S. R. F. A., 937:

1. What are the posts of the cannoneers to move by hand the carriages limbered?

2. Give posts of cannoneers, carriages unlimbered but not prepared for action (using 1902 model caisson and 1916 model caisson).

3. After carriages are unlimbered and in position, what determines the front?

4. What are the commands to move by hand the carriages unlimbered?

5. (a) Who sets and releases the brake on 1902 model caisson?
   (b) On 1916 model caisson?

6. (a) At the command "Caissons Forward," using 1916 model, in which direction is the caisson moved?
   (b) Is it turned around before being used?

7. Carriages unlimbered and being moved by hand, command "Halt" is given:
   (a) What do cannoneers do?
   (b) What posts do they take?

8. What is the distance between the gunner and No. 2, and No. 4 and No. 3, using 1916 model caisson at their posts, carriages unlimbered but not prepared for action?

9. Command was "Caissons Forward" and cannoneers have taken their posts, what takes place now at the command "Caissons Backward"?

10. (a) When do gunner and No. 2 lift the trail?
    (b) When do No. 4 and No. 5 lift the trail?

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Eighth Set.

Assignment for study: D. & S. R. F. A., 200:

1. What are the posts of the cannoneers, carriages limbered?

2. In what formation are the carriages placed before the command "Action Rear" is given? On which side is the caisson?

3. Give posts of cannoneers in unlimbering.

4. Which wheel does No. 2 go to in unlimbering? No. 3?

5. In "Action Rear" which element establishes the position?

6. Which cannoneer is in charge of the caisson? With which hand does he signal limbers to move off after unlimbering?

7. Explain how 1902 model caisson is placed in position after unlimbering in "Action Rear."

8. What is position of caisson after being established in position?

9. What is disposition of limbers after unlimbering?

10. Using 1916 model caisson, how is it moved in place beside gun after unlimbering?

Ninth Set.

Assignment for study: D. & S. R. F. A., 203:

1. At the command "Limber Rear," who releases the brake on the caisson:

   (a) Model of 1902?

   (b) Model of 1916?

2. What are the duties of No. 3 at the command "Limber Rear"?

3. How far is the caisson moved to the rear at the command "Limber Rear"?

4. Do all cannoneers assist in the movement of the caisson?

5. Which cannoneers work at the trail in "Limber Rear"?

6. After the caisson has been moved to the rear, what do the cannoneers do?

7. At the command "Limber Rear," which way is the trail moved with respect to the piece?

8. What are the posts of the cannoneers in "Limber Rear," just before "Limber Halt" is given?

9. In turning the caisson, which way is the wheel on which No. 6 works turned with respect to the trail?

10. Who lifts the caisson prop at the command "Limber Rear" (caisson model 1916)?

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Tenth Set.

Assignment for study: D. & S. R. F. A., 201:

1. If the command "Action Right" is given while the carriages are moving, when do the cannoneers dismount?
2. Who unlatches the pintle of the caisson when the command "Action Right (Left)" is given?
3. How do the drivers know when to move off with the caisson limber?
4. What does No. 2 do if the command "Action Left" is given while the carriages are moving?
5. Who unlatches the pintle of the piece in "Action Right"?
6. In "Action Right," what becomes of the limbers?
7. Which carriage establishes the position in fire to the flank?
8. Which limber moves out first in fire to the flank?
9. How far from the line of guns are the limbers posted?
10. In action right, what cannoneers bring up the carriages in rear and place them in position?

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CHAPTER V

FIRE DISCIPLINE

BEFORE teaching fire discipline, the instructor should have thoroughly fixed in his mind the distinction between INSTRUCTION and DRILL.

During the former the language used should be as simple as possible, and the meaning of all technical terms which are necessary should be carefully explained. A conversational tone should be adopted, and under no circumstances whatever should anything in the nature of long quotations from drill books be allowed. The men should be permitted to assume an easy attitude and their interest should not be allowed to flag. **They should be encouraged to the fullest degree to ask questions.**

At **drill,** on the contrary, the **most rigid** discipline must be maintained, orders must be **clear, decisive,** and **EMPHATIC,** and the detachments made to work steadily, smartly, and rapidly. At the same time the utmost accuracy is essential, and any deviation from the methods laid down must be **at once** strictly checked.

If at any time during fire discipline drill the interest seems to lag or if the drill becomes slow, give a few movements of "drill of the gun squad," until the cannoneers liven up.

The course in fire discipline has been laid out in hours and as so covered has proven satisfactory. By following this schedule and using in conjunction the Drill Regulations all difficulties with the subject are removed. The paragraphs where noted refer to the D. & S. R. F. A. With each hour is given the equipment that should be at hand to give the best drill.

1st Hour. Paragraphs 938 to 943 incl.

Equipment: Four gun sections, four panoramic sights, four quadrants.

When commencing the instruction in the first hour, if there are any men who have had instruction in firing battery drill, four should be picked to act as permanent chiefs of section for the hour. Until the members of the section become familiar with the drill this should

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be done each hour. Later everyone should be given an opportunity to drill in each position of the gun squad. Four gun squads are selected consisting of a gunner and six cannoneers. They are posted in rear of their pieces. If there are more men they should be formed into gun squads and one squad posted in rear of each of the first four squads. These should observe the drill carefully and by observation each number should learn his duties by following the work of the corresponding number in one of the first four squads.

In order to give a relative rating to the members of the section based on the mistakes they make at drill the following is suggested. A slip of paper is ruled in columns. In the first column appears the numbers of all cannoneers typed consecutively down the sheet. The next is headed mistakes and a third is provided in which to write the name of the cannoneer opposite the number or position he held in the squad. The number six of each squad is given the slip and all during drill he places a check in the column of mistakes opposite the proper number whenever the cannoneer of that number is criticized by the instructor. This enables the instructor to keep an accurate record of mistakes and at the same time devote all his attention to the drill. At the end of the hour these slips give by comparison the relative merit of the work done by each cannoneer. To mark on the 100% basis give a weight of five to each check. The resulting grades can be recorded and weekly or monthly standings announced.

As no instruction has as yet been given in "Positions of the carriages after unlimbering," the instructor should have the carriages unlimbered in the gun sheds and the caissons and pieces run out and placed in their proper relative positions for firing. No explanation of this is necessary now. The sections should be placed at intervals of four yards.

The instructor in teaching "Prepare for Action" should impress upon the minds of the men the importance of each cannoneer performing his duties in the exact order prescribed, as they are so linked together that this is absolutely necessary. Explain each duty of each cannoneer and as this duty is explained have the cannoneer execute it. All other cannoneers should group around so that they see what is being done and should be warned that they will be responsible for all the duties of all the cannoneers. If a cannoneer arrives at any particular duty and finds that any part of the matériel is missing, he should call out the reason for not performing that duty, *i.e.*, "Front sight out of order," etc. First explain that the gunner removes the sight shank from its case, **placing the case back in the trail box and closing down the top.** All

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should be instructed in placing the sight shank in the bracket. The shank is grasped by the left hand just below the peep sight, the scroll gear handle by the right hand. Bracing his right arm against the piece, the gunner pulls out the scroll gear handle and inserts the shank in the bracket until the index points almost to 3000. The scroll gear handle is released and then turned until the reading on the sight shank is 3000. He then sets the deflection on the peep sight at zero. He takes the panoramic sight from its case. All members of the gun squad should now be shown how this is done. The gunner opens the sight box, grasps the sight around the shank and hood with his right hand, back of the hand up, thumb to the left. He removes the sight, turning it to an upright position, and places it in its socket. The top of the sight box should be put down. The gunner should now lock the sight in its socket. Each member of the gun squad should be made to actually do this himself. The gunner then sets the deflection at zero, and the elevation index at 300 (panoramic sight, model of 1915). Now explain that the next duty of the gunner is to assist in raising the top shield but that he should wait until No. 1 reaches that point in the performance of his duties. Explain the duties of No. 1. He removes the quadrant from its case. All cannoneers should be instructed how to do this. No. 1 should grasp the quadrant with the right hand, back of the hand up, the first and second fingers grasping the spring handle and compressing the spring. He removes it from its case, closing down the top. He turns the quadrant so that the back of his hand is down and places it in its seat. He centers the cross level bubble, sets the range at 3000, the site at 300, and brings the range bubble to the center. The instructor should explain that the elevating crank handle starting from the top moves in the same direction as the bubble so that before the cannoneer starts to turn the handle he should look to see in what end of the dial the bubble is situated and then should turn the handle accordingly. No. 1 equips himself with a lanyard and a wiping cloth, placing the lanyard around his neck, handle to the left. He operates the breech mechanism, examines the breech block, bore, and chamber, cleaning any parts requiring it, leaving the breech open, except when the gun is loaded. Now **both** the gunner and No. 1 should raise the top shield and seat themselves on their seats. The instructor then explains the duties in detail of No. 2. After No. 2 removes the breech cover he places it under the left trail handle. The handspike should be **engaged** before No. 2 goes around to the front of the piece. The instructor explains that the next duty of No. 2 is to assist in lowering the apron but that No. 2 should wait for No. 3. No 2, after lowering

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the apron, should distribute tow or waste to the cannoneers and take his seat on the trail handspike, straddling it, both feet on the ground. The duties of No. 3 should now be explained. Impress upon the cannoneers that no one should run between the caisson and piece. No. 3, after removing the muzzle cover (if it is not fastened), will place it on the left trail seat; also the front sight cover. He should take care to place these away from the sight bracket cover which the gunner has placed there. **All** cannoneers should be made to place the front sight in its firing position so that they will thoroughly understand it. Now **both** No. 2 and No. 3 lower the apron, catching it on one foot and **letting it down easily.** The instructor then cautions No. 2 to complete his duties as prescribed and informs No. 3 what his remaining duties are. No. 3 should wait to perform them until No. 4 has let down the fuze setter. No. 4 and No. 5 together should be instructed in their duties. Explain that in "Prepare for Action" they work from the bottom of the caisson up. Have No. 4 and No. 5 lower the apron as explained for No. 2 and No. 3. No. 4 then removes the cover from the fuze setter and if it is not fastened he places it on the chest. He lowers the fuze setter, letting it down easily. No. 4 and No. 5 complete their duties. As soon as the carriages have been prepared for action the chiefs of sections face toward the executive and report "No. 1 in order, sir," etc. The instructor should impress upon the cannoneers that under no circumstances will covers be placed on the ground.

The cannoneers should be instructed in their positions, carriages unlimbered and prepared for action. The instructor must demonstrate, **himself,** each position to **all** the cannoneers **assembled.** The position of the gunner is as follows: He is seated astride the left trail seat, right leg to the rear. He should slide to the rear so that the seat is under his left thigh and his left knee is practically hooked on the seat. His right knee is almost on the ground. His right shoulder is against the shoulder guard and his **entire weight** is against the breech of the piece. His right arm is hanging loose in front of the seat support. His left hand grasps the traversing hand wheel. No. 1 is seated astride the right trail seat, left leg in rear. His left arm is crooked around the operating lever at the elbow. He sits squarely on his seat, his right forearm resting on his right knee. No. 2 should sit astride the trail handspike, both feet on the ground, both hands grasping the trail handspike in front of him. No. 3 is sitting on the ground, legs extended, knees slightly bent, back against the right wheel of the caisson. His right hand grasps the corrector worm knob, his left hand, the range worm crank

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handle. No. 4 should bend over the fuze setter. No. 5 should be crouching behind the caisson. The chief of section kneels on his right knee directly in rear of No. 3 and even with the float. ALL CANNONEERS MUST BE CAUTIONED TO KEEP UNDER COVER. THE GUNNER AND NO. 1 SHOULD BE CAUTIONED THAT THE TOP SHIELD SHOULD BE UP AND ALL WINDOWS CLOSED UNLESS THE CONTRARY IS ABSOLUTELY NECESSARY. The instructor should pay particular attention to these two points.

The instructor in explaining "March Order" should emphasize the fact that the duties prescribed are performed in exactly the reverse order from those prescribed for "Prepare for Action." The method of instructing is exactly the same as in "Prepare for Action." Go into the minute details at first. The gunner and No. 1 lower the top shield and **fasten it.** The gunner then sets the deflection at zero on the panoramic sight and returns the sight to its case. Each cannoneer should be shown how the latter is done. The gunner, after unlocking the panoramic sight, grasps it at the hood and shank with his right hand, back of the hand to the right. He removes the sight from its socket, lowers the rotating head to the horizontal, the head moving to the left. The sight is then placed in its box, the box closed and fastened by the snaps. The gunner then removes the sight shank and gets the shank cover from the trail box. The top of the box is left open for the present. The gunner holds the shank cover in his right hand by the flap, the open part of the cover toward him, drops the sight shank in the cover, deflection scale also toward him. The flap is then buckled and the sight shank put away in the trail box. The old model sight shank, which is graduated to 6500 yards, is placed in the box, deflection scale up. The new model sight shank, which is graduated to 8000 yards, is placed in the box, deflection scale down. The tops of the boxes are lowered and snapped. The gunner then completes his duties as prescribed. No. 1 assists the gunner in lowering and securing the top shield. Then he waits until the gunner completes his duties. Now the instructor explains in detail the remaining duties of No. 1. No. 1 closes the breech, returns the lanyard and wiping cloth, and fastens the top of the trail box; the gunner has already put away the sight shank. He sets the range at 3000 and the site at 300 (quadrant-model of 1902); the range at approximately 5500 and the site at 300 (quadrant-model of 1916). He grasps the quadrant, placing the first two fingers on the spring handle, back of the hand down. He releases the spring catch, removes the quadrant from its seat, turns the quadrant so that the back of his hand is up, and places the quadrant in the box. He lowers the top and secures

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it with the snap lock. The instructor should explain the duties of No. 3, as far as raising and securing the piece apron with the assistance of No. 2. No. 2 should assist No. 3 in this duty and then stand fast until his remaining duties are explained. The remaining duties of No. 3 are now explained. The instructor should emphasize the fact that all covers must be put on securely. No. 2 and No. 3 in raising the apron should pull it up with their feet until they can grasp it with their right and left hand respectively. Then they secure it with the apron latches. The instructor now should explain the remaining duties of No. 2. No. 2 *secures* the trail handspike. In fastening the breech cover, he passes the strap through the ring in the elevating and traversing lock before buckling it. In explaining the duties of No. 4 and No. 5 the instructor should bring out the fact that they work from the top of the caisson down in executing "March Order." Nos. 4 and 5 raise the apron as explained for No. 2 and No. 3. The chiefs of sections report "No. 1 in order, sir," etc., after the cannoneers have completed "March Order." After completing "Prepare for Action" and "March Order" in detail, the instructor should have them executed very slowly by all the cannoneers. In order to give each candidate a chance to perform all the duties the cannoneers should change posts after completing "Prepare for Action" and again after completing "March Order." REMEMBER THAT THE SECRET OF MAKING ALL MEN WELL-TRAINED CANNONEERS IS TO ROTATE EACH CANNONEER THROUGH EACH POSITION EACH INSTRUCTION PERIOD EACH DAY. The instructor should see that this is carried out to the letter and should get in the habit of giving the command "Gunners and all cannoneers change posts, March." In order to check each cannoneer in the performance of his duties in "Prepare for Action" and "March Order" assign the corresponding numbered cannoneer in the squad which is in rear of the piece to watch the same numbered cannoneer at the carriages. After the movements have been completed, call on the cannoneers in rear of the piece for mistakes. Each hour the drill should be begun and ended by a short review of "Prepare for Action" and "March Order." After the cannoneers have become proficient in the above the instructor should explain how to execute "Prepare for Action" on the march. The duties of the cannoneers are prescribed in detail in paragraph 939. This should be reviewed about twice a week.

2d Hour. Paragraphs 955 to 973, 985 to 987, Handbook of 3-inch Matériel, pages 153–164.

Equipment: Blackboard and chalk; 2 panoramic sights, (model of 1904); 2 panoramic sights (model of 1915); 1 sight

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shank, old model, graduated to 6500, 1 sight shank, new model, graduated to 8000; one 3-inch piece.

The instructor should make a detailed explanation of the deflection and deflection difference. Show graphically what deflection is and how it is measured. Explain only that part which applies to the firing battery. In explaining deflection difference use the first piece as the directing piece and use two pieces to illustrate. Then explain the application of deflection difference when three pieces and also four are used. Always make a graphical demonstration. Do not explain obliquity or parallax: simply show what angles are involved. Explain the application of the deflection difference when the aiming point is in rear and when in front. Explain the difference between direct and indirect laying and the indication of both.

The nomenclature of the panoramic sights should be made as simple as possible, leaving out the names of the unimportant parts. A detailed study of this will be made in the subject of matériel. Cannoneers should know the parts given below so that they will have a comprehensive idea of just what parts the instructor refers to during the drill. First explain the panoramic sight, model of 1904, and have the candidates memorize the parts given below:

Panoramic Sight (Model of 1904).

Rotating head.	Shank.
Rotating head window.	Eye piece.
Azimuth circle.	Worm knob.
T. lug.	Eccentric lever.
Horizontal and vertical cross hairs.	Worm index.

Now explain how the azimuth circle and worm index are divided, calling attention to the directions in which the rotating head points when the azimuth circle is set at 0, 1600, 3200, 4800, and 6400. Show the fast motion lever (eccentric lever) and how it is operated. The fast motion should be used for changes of 300 mils or over.

The worm knob should be grasped with the left hand between the thumb and forefinger, back of the hand away from the gunner. In order to apply a deflection shaft to the right (left) the knob should be rotated so that the thumb moves to the right (left). Explain that in order to take up the play in the gears that the knob is turned to the left (counter clockwise) in the last motion. Impress upon all that it is **absolutely essential** that this be done in order to have accurate firing. The azimuth circle should be first. Then the reading in the worm index should be added to the above. Impress

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upon the cannoneers that GUNNER SHOULD MAKE THE OPERATION OF SETTING DEFLECTION ABSOLUTELY MECHANICAL. HE SHOULD NEVER MAKE MATHEMATICAL CALCULATIONS IN HIS HEAD AND THEN APPLY THEM. Pass the two sights around to all and have each one make one setting and read it—do this quickly. Ask questions on the nomenclature.

Explain the panoramic sight (model of 1915) and have the cannoneers memorize the names of the parts given below:

Panoramic Sight (Model of 1915).

Elevation worm micrometer head.	Deflection dial.
Elevation index.	T. lug.
Rotating head.	Shank.
Azimuth scale.	Eye piece.
Azimuth worm lever.	Azimuth micrometer.
Worm knob.	Horizontal and vertical cross hairs.

Follow the same plan in explaining this model as used in connection with the 1904 model. The deflection and deflection changes which apply to the battery as a whole—*i. e.*, the original deflection and any changes right and left, are set off on the azimuth scale and azimuth micrometer. Any corrections which apply to the individual pieces such as the deflection difference, and any changes right and left for any particular piece, are set off on the deflection dial. Now give some examples. "Deflection 6250." This is set off on the azimuth scale and micrometer. In order to have a rule of thumb for turning the azimuth micrometer the right hand is placed on the micrometer so that the thumb is canted to the right. "Right 50." The thumb is moved to the right oblique (the azimuth micrometer turning away from the gunner) until the micrometer has moved 50 mils. The azimuth scale is read first and the reading on the micrometer added to it. "On No. 2 open 5." Assume that the instructor is representing the gunner of the fourth piece. The gunner grasps the worm knob as on the sight model of 1904 and applies the deflection difference (10 mils), moving his thumb away from the second piece, which would be on his right. One of the chief difficulties encountered in using the 1915 model is reading the scales, so that this point should be explained carefully. Continuing the problems above: the 0 (zero) on the deflection dial has moved 10 mils in the direction of the black arrow, the index on the front part of the hood is pointing on the black scale marked (L) and the black lines on the deflection dial are read. This means that 10 mils must

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be added to the combined readings on the azimuth scale and micrometer and the reading of the deflection is 6210. So that if the index on the front part of the hood points on the black scale (L) the reading in black lines on the deflection dial is added to the combined readings on the azimuth scale and micrometer. If the index points to the red scale the reading in red lines on the deflection dial is subtracted from the combined readings on the azimuth scale and micrometer. "No. 4 right 20." At this command the gunner turns the worm knob through 20 mils so that his left thumb moves toward the right, and the deflection now reads 10 mils on the red scale. The deflection reading is 6190. In brief, the azimuth scale is read first, the azimuth micrometer next and the deflection dial last. The elevating mechanism of the rotating head should be explained next. The reason for this is that if an aiming point is above or below the horizontal, the head can be tipped until the aiming point can be seen. This is operated with the left hand, and in order to take up lost motion the elevation worm micrometer screw is turned so that the thumb moves to the right (counter clockwise) in the last movement. Impress on the cannoneers that if **direct** laying is used that the elevating index has to be set at 300. Otherwise the line of sight is not in its proper position. The azimuth micrometer should be turned so that the thumb of the right hand moves toward the gunner in the last motion (counter clockwise), the deflection dial so that the thumb moves to the left in the last motion (counter clockwise). This is to take up lost motion in the gears.

The peep sight is operated with the left hand. Show how the deflection scale is graduated. The peep sight screw is turned so that the thumb (starting on top) moves away from the gunner in order to decrease the readings on the deflection scale. The last motion of the thumb should be away (counter clockwise) from the gunner to take up lost motion. The gunner in looking through the peep sight should have his eye about six inches from it. Explain the sight shank and range strip. Show how to use the fast motion in order to make a range of **over 500 yards.** The left hand grasps the sight shank just below the peep sight, the right hand grasps the scroll gear handle. The right arm is braced against the piece. The scroll gear handle is pulled out and the shank moved approximately to its required position. The scroll gear handle is released and then turned until the index is opposite the proper setting. The gunner in setting the range on the sight shank should lower his eye until it is opposite the index. The thumb of the right should move **toward** the gunner (counter clockwise) in the last motion of setting the range on the sight shank in order to take up lost motion.

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The scroll gear handle should be turned toward the gunner to decrease the range readings. Each man should be shown the two models of sight shanks. In order to level the cross level bubble the gunner grasps the leveling screw with the left hand. To move the bubble to the right the screw is turned toward the gunner (thumb starting at top).

3d Hour. Paragraphs 845–869; 955–956; 969.

Equipment: Four 3-inch guns; 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915).

Have the cannoneers memorize the duties in detail of the gunner. Give the commands for indirect laying, and have each man go through one problem. Have them line up in four columns in rear of the gunners' seats, one column at each gun. REMEMBER THAT EACH MAN SHOULD GO THROUGH EACH DUTY EACH HOUR. Consequently no time can be wasted in long explanations. Explain indirect laying first. As soon as the aiming point has been announced and the gunner identifies it, he reports, "Aiming point identified." Show that the gunner always starts at the top of the sight and works down in the order that he comes to his prescribed duties (panoramic sights—models of 1904, 1915). It is most important that all gunners FIRST set the deflection ordered and THEN apply the deflection difference. He sets the approximate range on the sight shank, levels the cross level bubble with his left hand, moving the leveling screw so that the thumb of the left hand starting at the top (counter clockwise) in the last motion moves away from him. He places his left hand on the traversing handwheel back of the hand up, and his right arm in front of the seat support. He traverses until the vertical hair of the panoramic sight is on the center of the aiming point. The last motion of the traversing handwheel should be (hand starting at the top) away from the gunner (counter clockwise) so that the breech moves against his shoulder. The gunner, after laying for direction on the aiming point, calls "Ready," and sits up on his seat drawing his feet under him but keeping them on the ground. His right hand should grasp the seat support, back of the hand to the rear. His left hand should grasp the side of the main shield. His eyes should be on the executive, and he should be careful not to lean against the wheel. At the command "Fire" of the executive the gunner repeats the command in a sharp, low tone of voice, and resumes the position he had before he said "Ready." The aiming point and deflection should be so chosen that no movement of the trail is necessary. The instructor should verify the settings and check to see that the vertical hair is on the aiming point. After all have had one problem

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in indirect laying the instructor should explain direct laying, giving one problem to each as before. The gunner, as soon as the target has been announced and he identifies it, reports "Target identified." The gunner works from the top of the sight down, viz.: Sets the deflection range, levels the cross level bubble, and places his left hand on the traversing handwheel as before, and his right hand on the elevating crank handle, back of the hand down. The traversing and elevating apparatus should be manipulated at the same time until the vertical cross hair is on the center and the horizontal cross hair at the bottom of the target. The last motion of the elevating crank handle should be hand starting at the top away from the gunner (counterclock wise), so that, the breech moves up and all lost motion is taken up. The remaining duties of the gunner are the same as before. The instructor should check all settings and see that the gun is laid accurately on the target. The upper window in the shield is about 400 mils wide so that an aiming point or target which has a deflection between 200 and 6200 can be seen without lowering the top shield. The shield is about 2000 mils wide, so that aiming points which lie between 200 and 1200 and 6200 and 5900 cannot be seen without lowering the top shield. FROM THE VERY BEGINNING THE INSTRUCTOR SHOULD INSIST THAT ALL LOST MOTION BE TAKEN UP IN THE SAME DIRECTION EACH TIME AS PRESCRIBED FOR EACH INDIVIDUAL CASE.

The instructor should save enough time at the end of the hour to explain how to measure a deflection, and if any more time is available, as many men as possible should go through the exercise. Follow the paragraphs in the drill regulations.

4th Hour. Paragraphs 845–869; 955–956; 969; 973–975. Handbook of 3-inch Matériel, pages 164–167.

Equipment: Blackboard and chalk; 2 quadrants—one graduated to 6500 yards and one graduated to 8000 yards.

The cannoneers should be questioned thoroughly on the work of the day before, for about twenty minutes. Explain in detail the site and how it is accounted for in indirect laying and also in direct laying.

The most important parts of the quadrant should be memorized.

Quadrant

Scroll gear.
Range disc.
Level micrometer disc.
Spring handle.
Range level.
Cross level.
Micrometer screw.
Level scale.
Leveling screw.

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The instructor should explain how the level scale and level micrometer disc are divided and that 300 represents the horizontal. Explain that 300 is a convenient number, and was taken so that no minus readings would have to be set off on the scale. To set the site, No. 1 should grasp the micrometer screw between the thumb and forefinger of the right hand, back of the hand down. The site reading is increased by moving the micrometer screw so that the thumb moves toward No. 1. The last motion of the screw should be toward No. 1 (counter clockwise) in order to take up lost motion. The cross level bubble is leveled by grasping the leveling screw between the thumb and forefinger of the right hand, back of the hand to the right. The bubble is moved to the right by moving the screw so that the thumb moves toward No. 1 (counter clockwise). The last motion of the screw should be toward No. 1 (counter clockwise) in order to take up all lost motion. Explain how the range disc is divided and what its least reading is. Explain how the scroll gear is pulled out for changes in range of over 500 yards. The left hand grasps the scroll gear handle, left arm braced against the piece, and fingers of the right hand pressed against the range disc to act as a brake. The handle is pulled out and moved up or down until the index is almost opposite the proper setting. Then the scroll gear is released and the handle turned until an exact setting is obtained. The range is increased by turning the scroll gear handle so that the thumb moves toward the piece. The last motion of the scroll gear handle should be toward the piece (thumb starting at the top and turning in that direction) in order to take up lost motion. Have each man set off a range and site (quadrant in its seat), and read the same.

5th Hour. Paragraphs 870–891.

Equipment: Four 3-inch guns; 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 quadrants.

Have everyone memorize the duties of No. 1. Give the commands for indirect laying and have each man go through one problem. They should be divied up into four parts, and a column formed behind each trail seat on the right. Insist that No. 1 perform his duties in the order prescribed. The breech will be open so that the first duty of No. 1 is to set and release the brake. Have each cannoneer actually do this. He sets the site with his right hand, the range with his left as prescribed above, unhooking his elbow from the operating lever just long enough to do this. He centers the cross level bubble with his right hand turning the leveling screw so that the last motion will be toward No. 1 (the thumb starting at the top and moving toward No. 1). Have No. 1 now close

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the breech, assuming that the piece has been loaded. Explain that No. 1 ordinarily closes the breech at any time depending, of course, on when No. 4 loads the piece. He grasps the elevating crank handle with his right hand and levels the range bubble. The handle starting at the top moves in the direction that the bubble should move. The last motion of the handle should be, starting from the top, toward No. 1 (counter clockwise). He calls "Set" and sits up on his seat, grasps the firing handle with his left hand, back of the hand up, fingers to the front, forearm vertical (on the brass firing handle) so that the elbow will not be struck by the breech. Using the firing handle which stands almost vertically, No. 1 grasps it in the most natural way—his first two fingers hooked around the handle, back of the hand to the rear, his right hand grasping the side of the main shield. The instructor representing the gunner, gives "Fire" and No. 1 pushes down **smartly** on the firing handle. He then opens the breech and hooks his left arm in it. Explain what the duties of No. 1 are in direct laying, but it is not necessary that each candidate perform them. He should set the range on the quadrant. No. 1 calls "Set" in direct laying as well as in indirect.

Explain how to measure the site. Follow the drill regulations exactly. Explain in detail why **any convenient range** can be set off on the sight shank and range disc instead of the exact range of the target. Have each candidate go through this exercise. In order to save time appoint a gunner, and after announcing the target and range have the gunner lay on it while No. 1 is measuring the site. For example: The command being "Measure the site" 2800, the gunner lays on the target with deflection zero, range 2800, while No. 1 sets off 2800 on his quadrant and measures the site. The instructor should verify the settings of No. 1.

If there is any spare time, review the duties of the gunner by combining them with those of No. 1 and giving problems for both. Have the cannoneers who used the panoramic sights (model of 1904) use the other model, and vice versa.

6th Hour. Paragraphs 892-901.

Equipment: Four 3-inch guns; 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 quadrants.

Gather all the cannoneers around one gun and explain the position of No. 2 in shifting the trail. He should stand with his feet about 18 inches apart, grasping the trail handspike with both hands. The width of the float and the spade should be told them. No. 2, as soon as he has taken his position seated on the trail hand-

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spike after the carriages have been prepared for action, should mark lines in the ground directly in rear of the spade. These lines should be about 50 mils apart (⅓ the width of the trail), the first line at the center of the spade, five other lines being marked on each side of the center. The instructor should emphasize that No. 2 shifts the trail in one movement. He does not take two or three in order to get the trail in its proper position. Show No. 2 that if he desires to shift the trail 150 mils to the right, for instance, he places the left edge of the spade where the right edge was, or if the lines have been marked in rear of the spade the center of the spade is moved over three spaces. No. 2 should move the trail **only** in the cases mentioned below:

a. To give the piece its initial direction. This is done at the direction of either the gunner or the chief of section—usually the latter, but NEVER BY BOTH AT THE SAME TIME. If the gunner desires the trail moved he gives the command "Muzzle right (left)." "Trail down." He does **not signal with** his hand. The chief of section directs a movement of the trail by moving the palm of either hand in the proper direction, his arm extended toward the trail. He drops his hand or commands "Trail down" when the direction is correct.

b. When a change of deflection of **50 mils** or more is given. He moves the trail in this case without command.

c. Whenever the gunner or chief of section desires to have the trail shifted.

Now send the squads to their proper pieces and post the gunners and No. 2's. Have the others rotate in the positions of gunner and No. 2. Practice No. 2 in giving the initial direction by announcing "Target that house," and having No. 2 point the piece in that direction. The gunner then measures the deflection to the house, thus checking No. 2. After this is completed, give problems in shifting the trail in indirect laying. Have the gunner lay on an aiming point with some convenient deflection. The gunner then notes his deflection. The instructor then commands "Right (left) 100." No. 2 shifts the trail 100 mils in one movement and takes his seat on the trail handspike. As soon as No. 2 has completed the movement the instructor gives the command, "Measure the deflection," and the gunner measures the new deflection. The instructor causes the gunner to call out the change in deflection, thus checking No. 2. The gunner should always traverse the piece to the center when the trail is moved except in firing at a moving target. If time permits, practice the gunner, No. 1 and No. 2 on problems in direct and indirect laying.

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7th Hour. Paragraphs 870–901; 980–984; Handbook of 3-inch Matériel, pages 53–58; Handbook of 75 mm. Gun Matériel (model 1917, British), pages 27–29.

Equipment: Blackboard and chalk; 2 bracket fuse setters (model of 1905M); 2 bracket fuse setters (model of 1916); 2 hand fuse setters (model of 1905M); 2 hand fuse setters (model of 1912); 2 drill cartridges.

Spend the first twenty minutes of this period in questions on the duties of No. 1 and No. 2.

Explain in detail what is meant by the corrector, raising and lowering the same.

The nomenclature of the bracket fuse setters (both models) is the same. Have the cannoneers memorize the parts given below:

Bracket Fuse Setter.

Corrector scale.	Guide.
Corrector worm knob.	Stop.
Range ring.	Rotating pin notch.
	Range worm crank.

Explain how the corrector scale and range are divided and the least reading of each. Explain what "S" means in the range ring, and that if the range ring is set at "S" and the corrector at 30, the projectile, if set, will be at "Safety." Explain the function of the "Stop" and "Rotating Pin Notch," using the drill cartridges. Impress upon all that it is important for No. 3 to know in which direction the corrector worm knob and the range worm crank should be turned in order to change the corrector and range to any particular setting. In order to increase both the range and corrector settings the range worm crank, handle starting at the top, and the corrector worm knob, thumb starting at the top, turn toward each other. The last movements should also be in that direction in order to take up all lost motion. Have each man set the corrector and range.

Have the cannoneers memorize the parts given below:

Hand Fuse Setter (model of 1905M).

Range ring.	Stop.
Handle.	Rotating pin notch.
Corrector scale.	Wing nut.

The corrector scale and range ring are divided the same as in the bracket fuse setter. In setting this model of the hand fuse setter

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the sliding index is placed opposite the desired corrector setting with the right hand, the fuse setter resting in the palm of the left. The left thumb is then placed on the index, holding it in place, and the range set opposite the index by turning the handle with the right hand. The wing nut should then be tightened, thus clamping the corrector and range at their proper settings. The handle is turned in a counter clockwise direction to increase the range. All the cannoneers should be practiced in setting this fuse setter once. Explain that the hand fuse setters are only used as substitutes for the bracket fuse setters.

Have the cannoneers memorize the parts named below:

Hand Fuse Setter (model of 1912).

Range ring.	Index.
Corrector scale.	Index bar.
Pointer arm.	Corrector worm knob.
Stop.	Range worm knob.
Rotating pin notch.	

Explain how the corrector scale is divided. There are two range scales—one for the 21-second fuse, and one for the Ehrhardt fuse. The index is moved on the index bar, and is set so that it touches the outside edge of the range ring for any particular fuse. The index is set at zone 3 for the 21-second fuse, and at zone 2 for the Ehrhardt. The pointer arm indicates when the fuse is set. The pointer should register with the gradual line on the closing cap. This pointer is necessary because it is very difficult with the 1912 model fuse setter to tell when the stop on the fuse is in contact with the stop on the fuse setter. Explain the method of operating the fuse setter as prescribed in the Handbook of the 3-inch Gun Matériel, page 58. The corrector worm knob is turned away from No. 3 to increase the corrector. The range worm knob is turned toward No. 3 to increase the range. No. 3 holds the fuse setter in his left hand and manipulates the knobs with his right. To take up all lost motion No. 3 turns the knobs so that the thumb starting at the top, placed on either one, would move away from the other. All men should be practiced in setting this fuse setter once.

8th Hour. Paragraphs 901–912.

Equipment: Four gun sections; 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 quadrants; 4 bracket fuse setters; 2 hand fuse setters (model of 1905M); 2 hand fuse setters (model of 1912).

Have the cannoneers memorize the duties of No. 3. They

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should be performed in the order given. Each cannoneer should be practiced in setting the bracket fuse setter first. Then the hand fuse setter. Two squads at each gun can be working at the same time, one at the bracket and one at the hand fuse setter. After all have finished interchange the squads. In this way time can be saved. No. 3 grasps the corrector worm knob between the thumb and forefinger of the right hand. He grasps the range worm crank with the thumb and forefinger of the left hand. He should place his head squarely above the fuse setter in order that the scale may be correctly set. He should be practiced in setting fuses with the hand fuse setters as soon as No. 5's duties have been explained. After No. 3 has set the corrector and range he calls "Cut" in a low tone so that No. 4 will know when to start to complete the setting of the fuse. Review the combined duties of the gunner, Nos. 1, 2, and 3 if time permits. Rotate as much as possible on the different model sights, so that each man will get a chance at each model every other day. When using the hand fuse setter No. 3 kneels on his right knee, facing to the left rear. He holds the fuse setter in his right hand and steadies the projectile with his left when setting the fuse. THE INSTRUCTOR SHOULD TAKE ENOUGH TIME HERE TO GIVE A SHORT LECTURE ON THE IMPORTANCE OF TURNING SCALES, KNOBS AND HANDLES IN THE DIRECTIONS PRESCRIBED; ALSO THE IMPORTANCE OF THE CANNONEERS KNOWING EXACTLY IN WHAT DIRECTION THE KNOBS AND HANDLES SHOULD BE MOVED TO INCREASE OR DECREASE THE READINGS ON THE SCALES.

9th Hour. Paragraphs 901–912; 944–951; 995–1002; 1025–1032. Equipment: Blackboard and chalk.

Spend the first fifteen minutes in questioning the cannoneers on the duties of No. 3.

The instructor should lecture on the composition and formation of the firing battery, duties in general of officers and non-commissioned officers of the gun squads. Expand on the subject matter given in the drill regulations giving illustrations and explain exactly what a battery does when it goes into position and the duties of all its officers and non-commissioned officers. In explaining the duties of the chief of section, the point should be brought out that if firing with a lanyard, the chief of section should caution "with the lanyard" in time so that No 1 can hook it in the firing shaft immediately after calling "Set." The chief of section should hold his arm **vertically**—not half raised. Explain in detail the manner in which the cannoneers assist one another in the service of the piece.

Explain what is meant by salvo fire. Bring out the fact that all instruments are kept set, even though the respective pieces to which

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they are attached, are not firing. Make each cannoneer count out two seconds over and over again until each one can judge it correctly.

10th Hour. Paragraphs 912–924.

Equipment: Four gun sections; 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 quadrants; 8 drill cartridges; 4 hand fuse setters.

Have the cannoneers memorize the duties of No. 4. Demonstrate using only one gun section at first. The exact position of No. 4 at the fuse setter is described in the drill regulations. Impress upon them that it is very important that No. 4 turn the projectile until it stops before removing it from the fuse setter. No. 4 should wait until No. 3 has called "Cut" before he starts to complete the setting of the fuse. In order to insure that the fuse is set, No. 4 should rotate the projectile clockwise as he removes it from the fuse setter. No. 4, in loading the piece, should jump off with the left foot first, take a step with the right foot, and then bring left foot up in front of the right, thus placing him in a position to load. Although the drill regulations prescribe stepping off with the right foot first, they contemplate only one jump and this is almost impossible to do smoothly. The instructor should impress upon the cannoneers that No. 4 should **spring** over to the breech with snap. In holding the projectile he should place the palm of his right hand flat against the base of the projectile, fingers extended and joined. His fingers may either be pointed up or down depending upon whether he is a short or a tall man. The former method is to be preferred, as it gives No. 4 a chance to get his eyes where he can see how to center the projectile before pushing it home. No. 4 should insert the round well in the chamber before completing the movement. As he shoves the projectile home he carries his right hand over the breech, so that there is no chance of getting his fingers jammed. IT IS IMPORTANT THAT THE CANNONEERS LEARN FROM THE VERY FIRST TO BE EXTREMELY CAREFUL IN LOADING BECAUSE, UNLESS THEY ARE, THE DRILL CARTRIDGES WILL BECOME USELESS IN A VERY SHORT TIME. No. 4, as soon as the gun has been loaded, resumes his position at the fuse setter. For drill purposes he does not grasp the new projectile but waits behind the fuse setter until the gun has been fired, and then jumps over to the breech and catches the ejected drill cartridge. He then jumps back and hands the cartridge to No. 5, who places it back in the caisson. In service firing No. 4 would not catch the ejected cartridge case, but would resume his position at the fuse setter, grasping the projectile which is in there, as prescribed. In order to practice in loading, assign

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No. 1's to all the pieces and divide the other cannoneers into four squads, one at each fuse setter. At the command "Load" of the instructor, No. 4 loads the piece as prescribed and No. 1 closes the breech. At the command "Unload," No. 4 jumps over to the breech and catches the ejected projectile. Do not explain his duties in "percussion fire" or "fire at will" yet.

Have the cannoneers memorize the duties of No. 5. Using one gun section, demonstrate the duties of No. 5 to all assembled. The method of removing a round from the chest and inserting it in the fuse setter is described in the drill regulations. No. 5 should insert the round so that the lug on the fuse falls just to the left of the rotating pin notch in the fuse setter. The reason for this is that upon turning the projectile the lug engages almost immediately. Great care should be taken by No. 5 not to thrust the projectile in the fuse setter. He should place it in there CAREFULLY in order to avoid spoiling the drill cartridges. Using all four gun sections the cannoneers should be practiced in removing a round from the chest and inserting it in the bracket fuse setter. No. 5, when the hand fuse setter is used, faces to the right front, kneeling on his right knee. The round is placed with the base of the cartridge case against the right knee, the edge **resting on the ground.** The point of the projectile is up so that the axis of the round is pointed in the direction of No. 3's head. No. 5 grasps the round with both hands, the right arm resting on the right thigh, back of the right hand up. The left arm rests against the outside of the left leg, the elbow hooked over the knee, back of the left hand down. The left hand grasps the projectile about three quarters of the way up. All men should be taught how No. 5 passes a round to No. 4, either in percussion fire or when using the hand fuse setter. The method used in percussion fire is described in the drill regulations. The following change is necessary when the hand fuse setter is used. No. 4 passes his left arm over the right arm of No. 5, and grasps the projectile with his left hand between those of No. 5. In order to receive a round properly, No. 4 must stand immediately in rear of No. 5. The cannoneers should all be practiced in passing and receiving rounds. With the 1916 model caisson, No. 5, when the hand fuse setter is used, kneels down on the right of the trail.

If time permits a short SLOW drill of the firing battery combining duties of all the cannoneers should be held, giving problems in direct and indirect laying. Four chiefs of sections should be assigned to each squad. These should be the best in the drill of the firing battery. A chief of section should spend all of his time before the command "Ready" checking up on members of the gun squad.

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After the command "Ready," he kneels down in rear of No. 3, even with the float, and raises his right arm vertically, keeping his eyes on the executive.

11th Hour:

Equipment: Four gun sections; 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 quadrants; 8 drill cartridges; 4 hand fuse setters (model of 1912).

Before attempting to conduct a drill of the firing battery, the following forms should be made out:

Data

First Problem. Illustrating—indirect laying—time fire—deflection difference change on each of the four pieces—deflection change of over 50 mils (for No. 2)—method of fire "Battery Right."

Df. 5330	On No. 2 Op-10	Si-310	Kr-28	BR	1800	5320 5330 5340 5350
Rt. 100	On No. 4 Op-5		D-5 (23)		1600	5205 5220 5235 5250
Lt. 20	On No. 3 C1-10		Up-6 (29)		1700	5245 5250 5255 5260
	On No. 1 C1-5				1700	5245 5245 5245 5245
			Up-3 (32)	B-1	1600	
				B-2	1700	

Second Problem. Illustrating—indirect laying—shell fire—difference change on each of the four pieces—deflection change of over 50 mils (for No. 2)—method of fire "Battery Left."

Df. 2870	On No. 3 C1-5	Si-275	Shell BL	2800	2880 2875 2870 2865
Rt. 20	On No. 1 C1-10			3200	2860 2845 2830 2815
Lt. 70	On No. 4 Op-10			3000	2900 2895 2890 2885
Lt. 10	On No. 2 Op-10			2900	2900 2905 2910 2915
				2950	
				2925	

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Third Problem—Illustrating—indirect laying—percussion fire—deflection difference change on each of four pieces—deflection change of over 50 mils (for No. 2)—method of fire "Right Right"—change of site.

Df. 3480	On No. 4 Cl–10	Si–295	Percussion	RR	2800	3510 3500 3490 3480
Rt. 50	On No. 1 Op–5				2400	3460 3455 3450 3445
Lt. 20	On No. 3 Op–5	Si–285			2600	3470 3470 3470 3470
Lt. 30	On No. 2 Op–5				2500	3495 3500 3505 3510
					2450	
					2425	

Fourth Problem—Illustrating—indirect laying—individual changes in deflection for each piece—method of fire "Left Right"—volley fire sweeping.

Df. 980	On No. 1 Cl–5	Si–280	Kr. 25	LR	2700	980 975 970 965
No. 1 Rt. 10			D–3 (22)		2300	970 975 970 965
No. 2 Lt. 5	On No. 1 Op–5				2500	970 985 980 980
	On No. 4 Op–10		D–3 (19)		2600	940 965 970 980
			B–3 Sweeping		2500	

Fifth Problem—Illustrates—direct laying.

Df. 10	Kr. 25	BR	2300	10 10 10 10
Rt. 30	D–5 (20)		2100	6380 6380 6380 6380
		B–2	2300	

Sixth Problem—Illustrates—"fire at will." Target, approaching infantry, "Fire at will."

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Seventh Problem—Illustrates—firing at a moving target—Target—infantry moving from left to right.

Df. 6390	Kr. 30	B–1	2400 Fire
	D–3 (27)		2600 Fire
	Up–2 (29)		2400 Fire

Eighth Problem—Command—"With the hand fuse setter."

Ninth Problem—Illustrates—"Reciprocal laying"—aiming point. . . .

Df. 3250	Lay on No. 2.

The above problems illustrate all methods of laying, methods of fire, etc., prescribed in the D. and S. R. F. A. They should be written neatly in a note book in the form given. Do not try to make up problems on the spur of the moment, because the drill will lag and the cannoneers will suffer.

There will probably not be an aiming point which will agree with the deflection in the problems. This does not require making out numerous problems to agree with all aiming points. If, for instance, an aiming point was chosen in the left rear which required a deflection of about 3600 mils, and the deflection in the problem in your note book was 5830, in order to preserve the battery front, simply announce "Deflection 3630," etc., keeping in mind, when a check is made, just what the first two digits were that you announced. With practice this becomes very simple.

The deflections of each piece are written in order from top to bottom, the deflection of the first piece on top.

The drill of the firing battery should be very slow at first. The instructor should pay particular attention to see that the cannoneers are performing their duties exactly as prescribed. Accuracy should come first and speed later on. The instructor should impress upon the cannoneers the fact that the chief of section ought to be the busiest man in the gun squad. Although he **should not keep a record of the data,** he should know it so that he can give it to any member of the gun squad if necessary. The chief of section should check the settings of as many scales as he has time for before the gunner gives the command "Ready." Impress upon the men that it is just as much a mistake to forget the data as it is to set the wrong data on the scales. From the very beginning each cannoneer should **only concentrate on the part of the data which immediately affects him.** At first the instructor should give the data very slowly, allowing enough time between commands for each cannoneer to get his part of the data and start setting it. Instructors should

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pay particular attention to announcing the data correctly as prescribed in paragraphs 52 and 53 of the drill regulations.

During part of the drill each day the instructor should have the first shots in some of the problems fired with the lanyard. He should announce the fact before beginning the problem. **Immediately after the initial data has been announced** the chiefs of sections caution "With the lanyard." As soon as No. 1 calls "Set," he hooks the lanyard in the trigger shaft. When the gunner calls "Ready," all cannoneers step clear of the piece, No. 1 facing to the front holding the lanyard in his left hand.

The instructor should pay particular attention to see that the top shield is up and all windows closed, and all cannoneers are down behind the shields, so that as much protection is afforded as possible. The top shield may be down or one window open only if the aiming point is to the front or in direct laying.

The instructor must insist upon absolute quiet in the firing battery. All commands such as "Ready," "Set," "Cut," and those given by No. 4 in volley fire, should be given only loud enough for the chief of section to hear—no louder. A NOISY BATTERY IS A SURE SIGN OF POOR FIRE DISCIPLINE.

Instructors are cautioned to choose aiming points as far away as possible and near the same level with the guns. This prevents unnecessary delay in raising and lowering the sight shank and in moving the carriages.

There should be no saluting in the firing battery during drill. When anything goes wrong in a section so as to prevent firing, the chief of section faces the executive officer and reports "No. 1 out of order, sir." The instructor then gives the command "No. 1 out," and if the piece is loaded, the projectile is taken out and the trouble remedied as soon as possible. As soon as it has been, the chief of section reports, "No. 1 in order, sir," and the executive gives the command, "No. 1 in."

Nos. 3, 4, and 5 are the only cannoneers who move the caissons during firing. It is moved without command when the caisson assumes a dangerous or inconvenient angle to the piece. No. 4 should direct the movement. No. 5 removes the round from the fuse setter and places it back in the caisson. Assisted by No. 4, he lowers the caisson door and secures it. The carriage is then moved to its proper position only after the door has been closed and all rounds placed in the caisson. **The movement of the caisson must be done so that it does not interfere with the continuity of fire in the battery, consequently the fuse should be set at the last data, and the piece loaded before the carriage is moved.**

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The checking and grading system is adapted to this period of the instruction as follows:

No. 6 does all the marking, as was stated before, using the "Firing Battery Grade Sheets." In order to check all data the instructor causes the squads to fall in rear of their pieces, gives "AT EASE," and then commands "Check." As soon as the command "In rear of your pieces, FALL IN," has been given, the chiefs of section step up to the sight, and the one at the first piece reads the deflection and verifies the cross level bubble. If it is not in the center he turns it there, looks through the sight and reports "Deflection——, on (off) aiming point," if indirect laying is being used. If direct is used, the chief of section, after looking at the cross level bubble as before, looks through the sight, verifies the range, and reports, "Deflection—— (3200), on (off) target." The chiefs of sections should be sure in direct laying that the vertical hair is on the center of, and the horizontal hair on, the bottom of the target. In direct laying, when using the panoramic sight (model of 1915), the chiefs of sections should first verify the elevation index to see that it is set at 300, and his report would be: "Elevation——, deflection—— (3200), on (off) target." The chief of the second piece does the same thing, followed by the chiefs of the third and fourth pieces in rotation. As soon as each chief of section has made this report in indirect laying, he jumps the trail and verifies the setting of the site and range on the quadrant, and also the position of the cross level and range bubbles. He then reports "Site—— (3200), bubbles level (not level)." The chief of the first piece does this **immediately** after the chief of the fourth has reported on the sight settings. Each chief of section makes the second report in rotation, and after doing so goes to the fuse setter and verifies the settings there. They report in rotation, "Corrector——, 3200." If direct laying is used, the chief of section simply checks and reports on the range setting on the quadrant. In percussion fire no report is made on the corrector. The instructor should insist that the reports are made quickly and correctly. There is nothing that slows down the drill as much as slow checking. Too much cannot be said about marking and checking the cannoneer. Without it, the drill is valueless. Each man should be marked each day. In order to do this the instructor will have to pay particular attention to rotating the cannoneers in the different positions. At first this will be difficult, and the instructor should only give two changes in firing data and a check to each cannoneer. Later, when the candidates become more proficient, a complete problem can be given to each one.

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12th Hour. Paragraphs 912–924; 977–984; 1003–1007.

Equipment: Blackboard and chalk.

The instructor should spend the first twenty minutes questioning the cannoneers on the duties in detail of No. 4 and No. 5.

Explain briefly the different kinds of projectiles—shell, common shrapnel, and high explosive shrapnel—and their use. Explain the difference between percussion fire with shell or percussion shrapnel and time fire. Call attention to the fact that in percussion fire using percussion shrapnel, the fuses when set at safety burst on impact. Also the fuses are already set at safety in the caisson chest, so that when the brass cap is removed No. 5 has only to pass around directly to No. 4. Also, in percussion fire, a **shrapnel is left in the fuse setter,** so that if the fire is changed from percussion to time there will be no delay in setting the fuse. No. 3 always keeps his range set at the last one announced. In percussion fire, with either shell or shrapnel No. 4, as soon as the piece has been loaded the first time, immediately returns and gets another round from No. 5. No. 4 then takes his place in rear of the gunner and about two feet to the left of the trail, so that he will be out of the way of the gun when it recoils. No. 4 should hold the projectile in his hands, as prescribed for loading, so that no time will be lost. The piece is loaded immediately after the first projectile has been ejected. The same is done for each succeeding round. In order to permit No. 4 to perform his duties as prescribed, No. 2, as soon as the gunner has reported "Ready," jumps up on the right of the trail and receives the ejected round. He then steps back toward the trail and tosses the round to No. 5. No. 4 receives the **last** ejected round and passes it to No. 5. The instructor should caution the gunner and No. 1 not to report "Ready" and "Set" until after new data has come down, although the pieces have been loaded.

The instructor should explain when volley fire by battery and by platoon is used. He should caution the cannoneers that when acting as No. 4's they should call out the range and number of the round only loud enough for the chief of section to hear. The instructor, when using this method of fire in practical instruction, should **once in a very great while** use volley fire of more than one round. This is to avoid spoiling the drill cartridges. If volley fire of more than one round is used, No. 2 jumps up on the right side of the piece and catches all but the last round as they are ejected. No. 4 performs his duties as in percussion fire, except that he removes a round from the fuse setter instead of receiving it directly from No. 5. The chiefs of sections, as soon as their piece has completed firing the prescribed number of rounds, face the executive and report

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"Volley complete." The gunners **must re-lay** between each round in volley fire and the fire should never become so rapid that this cannot be done. The initial command for firing is given by the executive. As soon as the executive has commanded "Fire," all gunners repeat the command "Fire" **in unison.** After the initial round each gunner fires his piece when ready.

Volley fire sweeping may be used in direct or indirect laying. Explain where it is used. The gunners do not have to lay between rounds, but simply traverse the muzzle of the piece to the left by one turn of the handwheel after the first round and each succeeding one. In order to do this the handwheel is turned so that the left hand of the gunner (starting at the top) moves toward him. The gunner should be cautioned to **always** traverse back to the same part (the right) of the target that he laid the gun on before starting the sweep.

13th Hour. Paragraphs 1003–1007.

Equipment: Four gun sections; 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 quadrants; 8 drill cartridges; 4 hand fuse setters.

Drill the cannoneers as a firing battery, varying the problems as much as possible, paying particular attention to "Volley Fire" and "Volley Fire Sweeping." Use the bracket fuse setters during part of the hour and the hand fuse setters during the time remaining. Rotate the cannoneers so that they all may use both kinds of fuse setters and sights.

14th Hour. Paragraphs 1008; 1016–1024.

Equipment: Blackboard and chalk.

Question the cannoneers on all subjects covered up to date, bringing out the main points of each. Spend about thirty minutes on this.

Explain that "Fire at Will" is used only for the close defense of the guns, and that speed is desired more than accuracy. Consequently the gunner does not pay so much attention to re-laying after each round. The command "Fire" is given by the executive for the initial round. After that each gunner fires his piece when ready. No. 2 and No. 4 perform the duties prescribed for them in volley fire of **over** one round. The peep sight is habitually used in "Fire at Will." The instructor should explain why the corrector is set at 30 and the range at zero on the fuse setter, and the range at 1000 on the sight shank.

Have all the cannoneers memorize the firing data to be sent down to the guns and the exact order in which they are sent down.

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Impress upon them that it is absolutely necessary to follow this prescribed order. Explain also that when any member of the gun squad does not understand any item of the firing data he asks his chief of section thus, "Site?" "Corrector?" If the chief of his section does not know it, he asks the executive in the same manner.

15th Hour.

5. Equipment: Four gun sections, 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 quadrants; 8 drill cartridges.

Drill the cannoneers as a firing battery, varying the problems as much as possible (at least one of each type should be given), and laying the most stress on "Fire at Will." Give problems in both direct and indirect laying, rotating the cannoneers at the different model sights.

16th Hour. Paragraphs 967 and 968.

Equipment : Blackboard and chalk.

The instructor should give a graphic explanation of reciprocal laying, explaining every point in detail. The method prescribed in the drill regulations is so inaccurate that it is modified as follows: The instructor commands "Aiming point——deflection——lay on No.——" The gunner of the directing piece sets off the deflection ordered and lays on the aiming point. While he is doing this the gunners of the other pieces turn the heads of their panoramic sights toward the directing piece. Each of the No. 2's of these pieces hold a pencil or other thin object on top of the rotating head of the sight, the pencil being vertical, and on the center of the rotating head. If the pencils cannot be seen, the No. 2's use rammer staffs instead, holding them at the side of the rotating heads. The gunner of the directing piece, after laying on the aiming point, turns the head of his sight until the vertical hair is laid on the pencil on the first piece. The gunner should be careful not to disturb the laying of the piece by using the traversing mechanism, and should place his sight shank so that it will not have to be moved during the problem. The gunner then reads off the deflection of the piece on the right (not considering the directing piece) in this manner: "No. —— (four, five hundred and twenty)." He then reads the deflection to the other pieces in rotation, announcing them as before. In the meantime, as soon as the other gunners have received the deflections of their pieces, they apply them as follows: Those of the right of the directing piece add 3200 to the deflection announced, and set the result off on the sight. Those on the left subtract 3200 and do the same. As soon as the gunner of the directing piece has finished

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reading the deflections, No. 2 of that piece places a pencil on top of the sight as described above. The other gunners now lay their pieces on this pencil as an aiming point, and when laid sit up in their seats, so that the gunner of the directing piece can tell when their pieces are laid. The preceding operations are now repeated, with the exception of first laying on the aiming point announced. This is done because the first time the guns are laid the trails have to be moved, thus displacing the sights from the positions they were in when their deflections were measured. If the pieces would rotate on a perpendicular through their sights, this would not have to be done, so, to insure greater accuracy, the operations are repeated. As soon as the gunners of the pieces other than the directing piece have laid their guns the second time, the chiefs of sections of those pieces pick out an aiming point that can be seen through the sight, and each gunner then lays his sight on the aiming point assigned to him by moving the rotating head of the panoramic sight, NOT BY TRAVERSING THE PIECE. The gunner of the directing piece lays on the original aiming point the same way. As soon as each gunner has laid his sight he reads the deflection and writes it with chalk on the upper left hand corner of the main shield. Each chief of section, as the gunners have completed the above duties, report "No.——on aiming point." The instructor, in order to check the accuracy of the above operation, should have all the gunners lay their sights on a common aiming point, and read their deflections in order from right to left. If the guns are at equal intervals in line, and the sights are adjusted, the deflection differences should not differ by more than five mils. The instructor, in explaining this on the board, should take each piece in rotation as the directing piece and explain all the operations.

The instructor should give a graphical representation of laying on a high burst, explaining every point in detail. The pieces should first be laid approximately parallel by some convenient method, usually by reciprocal laying. First, assume that the first piece fires the round, the burst of which the others are going to lay on. The gunners of the other pieces turn the rotating heads of their panoramic sights in the direction in which they expect the burst. As soon as the burst occurs the gunners turn their sights on it, setting the vertical hairs on the burst. Each gunner and chief of section note the deflection. They will all be less than 3200 if the guns have been laid parallel. Each chief of section has his gunner turn the head of his panoramic sight on any suitable aiming point **without disturbing the laying of the piece.** The readings of the new deflections are noted, and then these diminished by the respective

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readings on the burst. The deflections obtained are then set on the sights, and all guns laid on their respective aiming points by traversing the pieces, thus converging the sheaf on the point of burst. Work out all possible solutions, assuming that each piece in rotation fires the round, the burst of which the other pieces lay on. Explain that this merely forms the sheaf, and the battery commander can now shift it or change the distribution by giving the proper commands.

17th Hour.

Equipment: Four gun sections; 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 quadrants; 8 drill cartridges; chalk.

The problems in reciprocal laying and laying on a burst should alternate in the above order, so that the pieces will be parallel before starting to lay on the burst. The instructor should have the cannoneers, who are not actually performing the work, pay **strict attention** to the problems. The first problem in reciprocal laying should be done slowly as prescribed in notes on reciprocal laying (second hour, fourth week). Each cannoneer should be given a chance to act as gunner in a problem of this kind.

After the guns have been laid parallel by reciprocal laying, the instructor should pick out some well-defined point as distant as possible, and as nearly in prolongation of the line of sight of the first piece as possible. This point must be visible from all the pieces. It should be assumed to be the burst of a projectile fired by the first piece. Have the problem completed as prescribed in notes on laying on a burst. In order to check the accuracy of the gunners, the instructor should look over the line sights on the piece and see whether it is pointed at the burst. After the pieces have been laid parallel again by reciprocal laying, assume that the second piece fires a shot, and complete the problem as before. If time permits, complete problems, using the third and fourth pieces as directing pieces.

18th Hour. Paragraphs 1012–1015; 1033–1043.

Equipment: Blackboard and chalk.

The instructor should give a graphic explanation of firing at a moving target, bringing out all the important points. The method of fire used in the attack on a moving target is volley fire, either by battery or by platoon, depending on the size of the target. The instructor gives the commands as follows: "Target, that troop of cavalry, moving from right to left; deflection 10, corrector 30, battery

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one round, one eight hundred, FIRE," or commands similar to these. The command "Fire" by the instructor is given immediately after the range, so that the gunners can fire whenever they are ready. The instructor should impress on the minds of the cannoneers that the gunner should keep the cross hairs of the panoramic sight laid on the target at all times, except between the command "Ready" of the gunner and the instant the round is fired. The gunner, as soon as he has set off the data, traverses the muzzle of his piece as far as possible in the direction opposite to that in which the target is moving. This is the only case where he does not have to traverse the piece to the center when No. 2 shifts the trail. The gunner follows the target without having the trail moved until the piece has reached the other end of its traverse. The gunner then gives the command for moving the trail, and No. 2 moves it about 130 mils in the proper direction. The gunner, as soon as he gives the command "Muzzle right (left)," traverses the piece as far as possible in the other direction, and immediately lays on the front of the target. When he is ready to fire, he reports "Ready," and straightens up quickly in his seat, assuming the position prescribed for the gunner, and gives the command "Fire." As soon as the piece is fired he starts to follow the target again. If the target goes behind some obstruction and cannot be seen the gunner traverses the piece at the rate the target has previously been moving. In order to be able to fire at a moving target, No. 2 should be absolutely coordinated with the gunner in the movement of the trail. The trail is moved about 130 mils at the gunner's command, because the traverse of the piece is about that much, and if the gunner traverses his piece back through 130 mils as No. 2 moves the trail the same amount in the opposite direction, the gun should be laid approximately on the target—if these operations are performed quickly. The instructor should explain that an initial deflection, either to the right or left, is necessary to allow for the time of flight of the projectile. Chiefs of platoons usually make any minor changes in the deflections in order to make the guns fire accurately on their targets.

The cannoneers should memorize the table prescribing how casualties are replaced. Form complete gun squads and have each candidate explain what duties he would perform if a member of the gun squad designated by the instructor is killed. The instructor **should assume all possible cases, as the replacement of casualties is particularly important.**

The instructor should briefly discuss the replacement of ammunition.

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19th Hour. Paragraphs 1012–1043.

Equipment: Four gun sections; 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 quadrants; 8 drill cartridges.

The cannoneers should be given practical instruction in firing at a moving target. The instructor should designate a cannoneer to act as the target. He should go out about 100 yards in front of the battery and walk up and down **very, very** slowly on a line parallel to the front of the guns. For the first few problems the instructor should halt the target and have all the gunners traverse their pieces in the proper direction and lay on the target. The instructor gives the proper commands for this as follows: "Target: infantry, moving from right to left, deflection ten, corrector thirty, battery one round, one eight hundred; do not load." After all the gunners have laid properly on the target the instructor signals the target to move, and the problem is continued. At first the instructor should wait until each gun has been fired before he gives any new data. Later on, when men become proficient in their duties, the target should start to move before the gunner originally lays his piece on it. Insist that the gun squads work **quietly** and **smoothly.** Each cannoneer should be given a chance to act as gunner.

The last half hour should be spent in a practical demonstration of the replacement of casualties. Give regular problems to the gun squads, calling out certain men as dead each time, and have the other members perform all their prescribed duties.

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POSTS OF THE CANNONEERS CARRIAGES UNLIMBERED AND PREPARED FOR ACTION
(1902 caisson)

This picture shows the cannoneers in the positions prescribed by Par. 941 D. & S. R. F. A. They are utilizing every available bit of cover. This is absolutely necessary.

"WITH THE LANYARD"

As soon as the initial data has been announced the chief of section cautions "With the lanyard." After calling "Set," No. 1 hooks the lanyard in the trigger shaft. When the gunner calls "Ready," the cannoneers assume the indicated positions.

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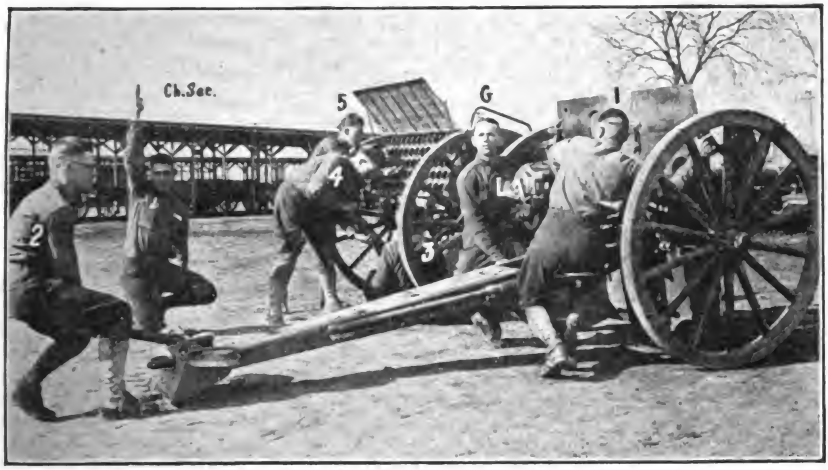

"READY"

Illustrating the correct positions of all cannoneers just before the piece is fired.

THE GUNNER BEFORE ANNOUNCING "READY"

When acting as gunner, remember to sit in the position shown above, with your entire weight against the breech, the left hand grasping the traversing hand wheel, right arm hanging free, looking squarely into the panoramic sight.

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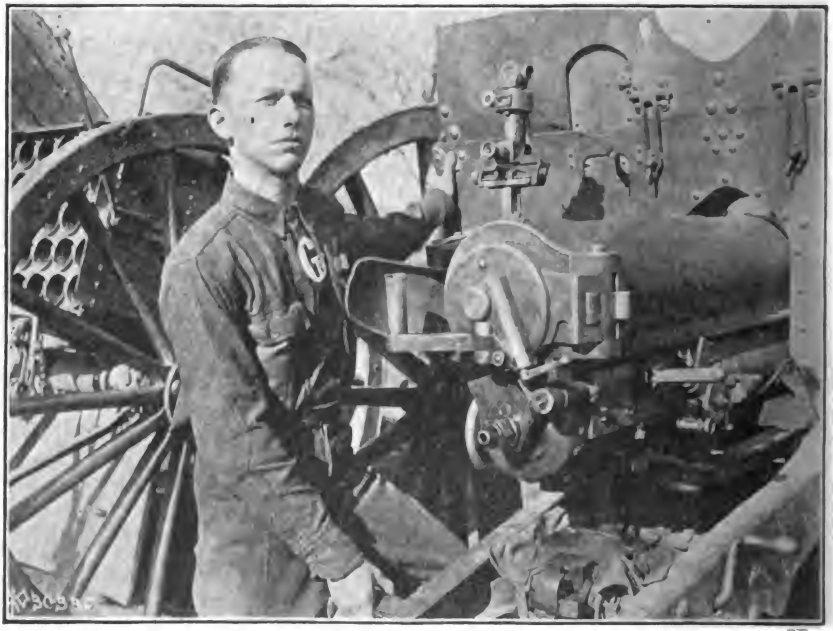
THE CHIEF OF SECTION

As soon as the gunner calls "Ready," the chief of section assumes the position illustrated, covering No. 3, opposite the float. This is a very important position, and should be emphasized.



THE GUNNER AFTER ANNOUNCING "READY"

As soon as the piece is laid, the gunner announces "Ready," just loud enough for the chief of section to hear him, sits up, eyes on the executive, hands as illustrated, feet drawn up under him, but on the ground. Never slouch against the wheel. He repeats the command "Fire," and resumes his former position.

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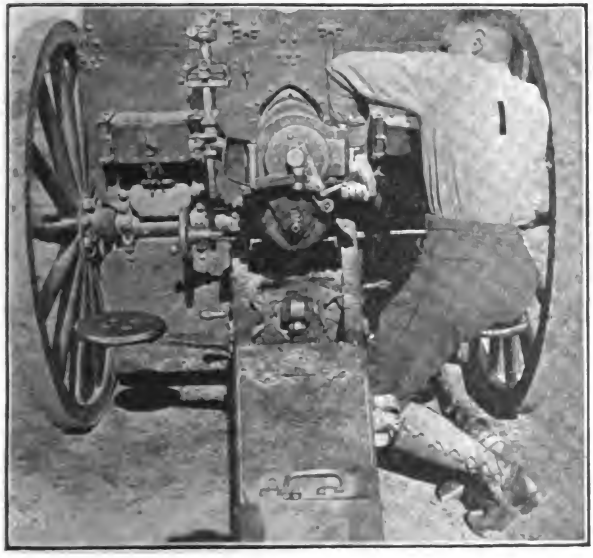
NO. 1 BEFORE ANNOUNCING "SET"

The breech block should be held open by crooking the elbow around the operating lever. No. 1 sets the site with his right hand, the range with his left, and then centers the cross level bubble with his right. He grasps the elevating crank with his right hand back up, and centers the range bubble in indirect laying. The head must always be kept well down.

NO. 4 INSERTING THE ROUND

Par. 915 D. & S. R. F. A. describes this position very minutely. Too much attention to detail cannot be given, as it is difficult to serve the piece with consistent accuracy. The right hand should be carried over the breech as the projectile is forced home.



NO. 1 AFTER ANNOUNCING "SET"

No. 1 closes the breech as soon as No. 4 loads the piece. He calls "Set" just loud enough for the gunner to hear, and takes the position illustrated. Note the position of his feet, and how the left hand grasps the firing handle with the elbow vertical. Eyes are on the gunner, the right hand grasping the main shield without slouching against the wheel.

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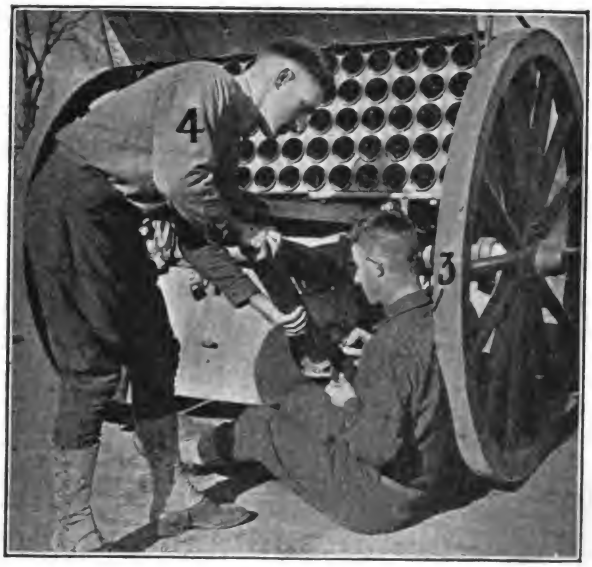
NO. 3 AT THE BRACKET FUSE SETTER

No. 3 sits with his back against the right wheel of the caisson, legs extended (never crossed), knees slightly bent, hands at all times in the positions illustrated, head squarely over the scales of the instrument.



NO. 4 COMPLETING THE SETTING OF THE FUSE

As soon as No. 3 announces "Cut," No. 4 stands in the position described in Par. 914 D. &. S. R. F. A., and turns the projectile to the right as far as possible, with a steady pressure of the right hand.

USING THE HAND FUSE SETTER
(1902 caisson)

Notice especially the position of the hands. It is very important that the fuse be cut in the manner prescribed in Par. 923 D. &. S. R. F. A. No. 5 should hold the round so that the axis is pointing at No. 3's head.

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PASSING THE ROUND
(Using the hand fuse setter and 1902 caisson)

No. 5 places the right hand under the center of the cartridge case, the left hand under the center of the projectile, and holding the round horizontally, he presents the base of the cartridge case to No. 4, who passes his left arm over the right arm of No. 5, grasping the balance of the projectile with his left hand, and the base of the cartridge case with his right.

NO. 5 REMOVING THE ROUNDS

Placing himself to the left rear of the round selected, No. 5 grasps the edge of the cartridge case with the fingers of the right hand, pulls the round to the rear with his left hand. A round should always be kept in the bracket fuse setter. D. & S. R. F. A., 920.

PASSING THE ROUND IN SHELL OR PERCUSSION FIRE

Executed exactly as described in Par. 924 D. & S. R. F. A., No. 4 taking the round from underneath.

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WAITING FOR THE INITIAL DATA

Notice that there is no slouching. The entire gun crew is on the alert; the chief of section and gunner are looking at the executive. Every available bit of cover is being used.

LAYING ON THE AIMING POINT

The chief of section is sighting along the rotating head of the panoramic sight and motioning to No. 2 to shift the trail. See the trail in the air, the gunner releasing the brake, and No. 2 looking at the chief of section's hand.

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SHIFTING THE TRAIL

The gunner commands "Muzzle right (left)," releases the brake, and centers the piece in traverse. No. 2, standing with feet eighteen inches apart, shifts the trail in the required direction with one slow continuous movement (NEVER A SERIES OF JERKS) until the gunner commands "Trail down." Note the eleven lines each 50 mils apart in rear of the spade.

"READY"

Notice especially the gunner and chief of section. No. 2 in service practice will jump to the right of the trail as soon as the piece has been fired, catch the ejected cartridge case, and throw it to the rear of the left caisson wheel.

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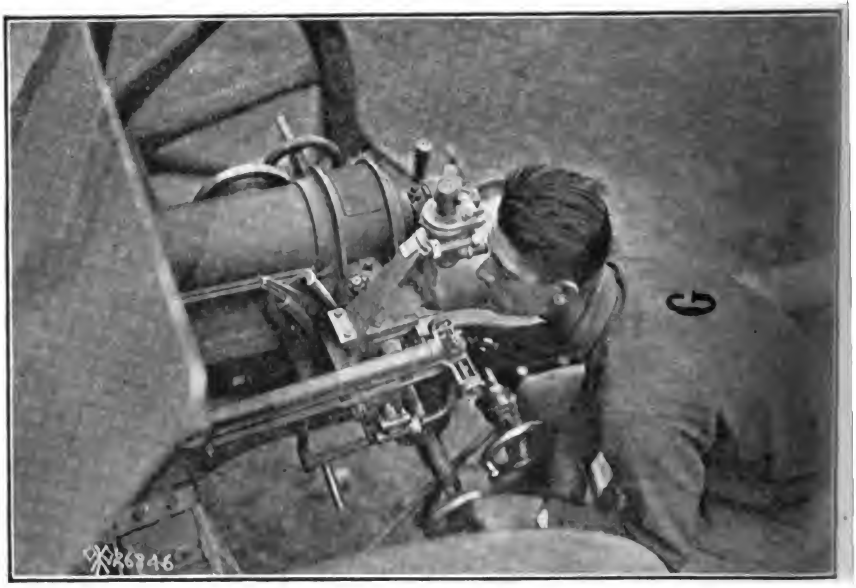

THE GUNNER BEFORE ANNOUNCING "READY"

Illustrating the following: 1. Right leg on the right of the traversing handwheel. 2. Right forearm resting on the right thigh. 3. Right arm just above the elbow in the hollow of the shoulder guard. 4. Left hand grasping lower elevating handwheel. 5. Looking squarely into the panoramic sight.

THE GUNNER AFTER ANNOUNCING "READY"

The gunner grasps the firing lever with his right hand as illustrated and looks immediately toward the executive.

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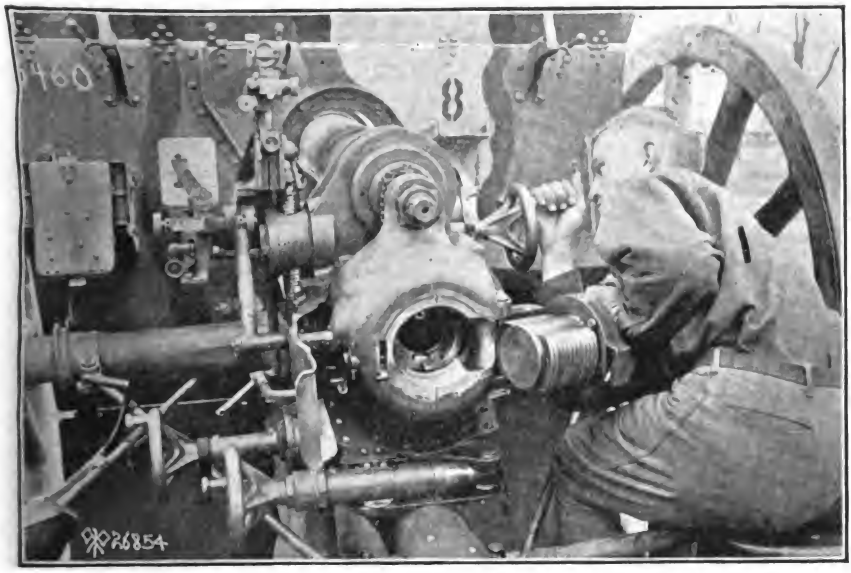
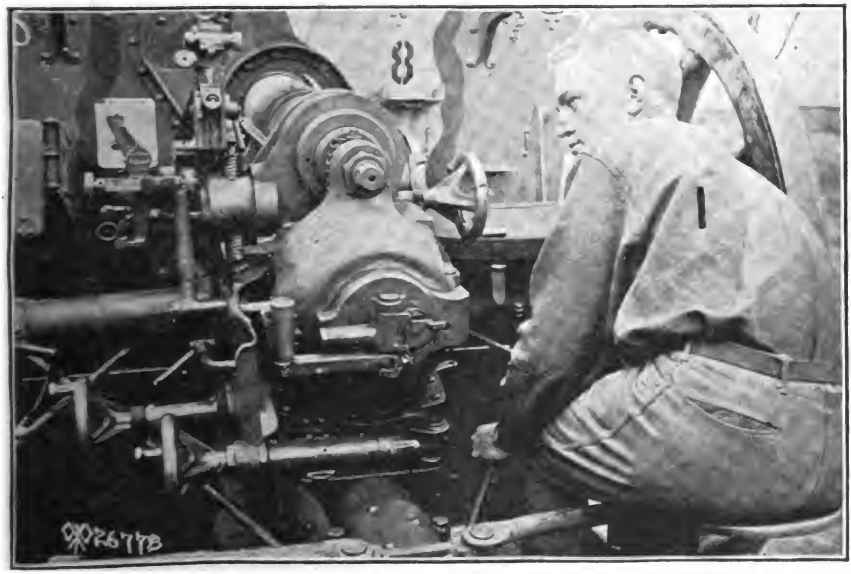


NO. 1 SETTING THE RANGE

Notice that the head is well down, the breech is held open, and the back of the right hand is to the front (always).



NO. 1 AFTER ANNOUNCING "SET"

With his left hand, he grasps the tensile stay. He is well clear of the breech, but not leaning against the wheel.

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NO. 5 SETTING THE FUSE

Leaning over the trail, No. 5 inserts the round in the Bracket Fuse Setter and turns it in a clockwise direction as far as possible, maintaining a constant pressure with his right hand against the base of the projectile, as previously described.

SETTING THE FUSE WITH THE HAND FUSE SETTER

Remember the position of No. 3's left elbow, left hand, and right knee, and No. 5's right foot, right and left hands, and left arm. Notice the method of holding the round so that it points at No. 3's head.

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PASSING THE ROUND

(Using the hand fuse setter and 1916 caisson)

As soon as No. 3 announces "Cut," No. 5 raises the round to a horizontal position, base toward No. 4, who takes it from above in the manner illustrated.

INSERTING THE ROUND

Stepping off with his left foot, No. 4 springs to the breech and takes the position indicated above. Head should be well down in order to center the projectile accurately, the front of the body parallel to the axis of the bore. This operation is very important.

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"MARCH ORDER"

At this command the gunner and No. 1 lower the top shield **immediately,** grasping the shield with the hand farthest from the wheel.

"MARCH ORDER"

Showing No. 2 releasing the pawl stud with his right foot and moving the traversing lever forward to its traveling position.

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Drill with British 75mm. Matériel

In the absence of regulations governing the drill of cannoneers with the British 75mm. Matériel (Model 1917) the following adaptation of the drill with the three-inch gun has been made. Here only the changes from the prescribed drill are noted. The nomenclature as used has been obtained from the Handbook of the 75mm. Matériel. The corresponding American term is given in parenthesis.

1st Hour. Paragraphs 181–182; 186–187.

Equipment: Four gun sections—British 75mm. Matériel (caisson model of 1916).

The **methods** of instruction should be the same for the drill of the gun squad and firing battery (British 75mm. Matériel) as prescribed for the 3-inch Matériel. Reference to the corresponding hours in "Drill of the gun squad" and "Firing battery (3-inch Gun Matériel)" will be given. The instructor **must review** these paragraphs and make the modifications prescribed for the British 75mm. Matériel. Only the modifications will be given below.

Posts of the cannoneers, carriages limbered. Gun squad drill, 2d hour.

Nos. 2 and 3 are opposite the rear of the limber wheels of the caisson. Nos. 6 and 7 in order from right to left are posted one yard in rear of the caisson, facing the chest. The center of the caisson door should be opposite the center of the four-inch interval between No. 6 and No. 7.

To post the cannoneers (181–182):

If the squads are formed in rear of the pieces, the carriages being in the formation "Battery in line," and the command "Cannoneers posts" is given, the gunner runs directly to his post. No. 1 takes one step to the right, waits until No. 2 has passed him and runs around the left of the piece to his post. No. 2 runs directly to his post, passing between Nos. 1 and 3. No. 3 follows No. 5 and runs directly to his post. No. 4 runs down the right side of the caisson to his post. No. 5 runs down the left of the caisson to his post. No. 6 runs down the right of the caisson, keeping well away from the carriage. No. 7 runs down the left of the caisson in the same manner.

To change posts. If the command **"Change posts, MARCH"** is given when the cannoneers have been posted at the carriages lim-

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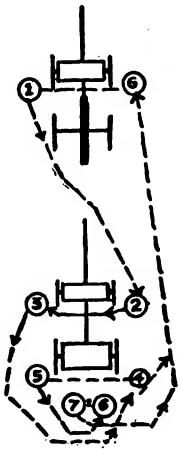
bered and in the formation "Battery in Line," the cannoneers change as shown in the diagram below:

If the command "**Gunners and all cannoneers change posts, MARCH**" is given the gunner and all cannoneers change as shown below:



To mount the cannoneers:

Nos. 2 and 3 mount on the limber chest of the caisson as prescribed for Nos. 6 and 7 (3-inch Gun Matériel). No. 6 mounts between Nos. 4 and 5. No. 7 mounts between Nos. 2 and 3. At the command "**Prepare to mount,**" the gunner and No. 1 take their positions for mounting (3-inch Gun Matériel). Nos. 2 and 3 hasten to the rear of the caisson limber, No. 2 on the right, No. 3 on the left. They take the same positions on the caisson limber as the gunner and No. 1 do on the piece limber (limber—Model of 1918—

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British). Nos. 4 and 5 take their positions for mounting (3-inch Gun Matériel, caisson model of 1916). No. 6 runs around to the right of the caisson and stands at attention two feet in rear of No. 4 facing in the same direction. No. 7 runs around the left of the caisson and take his position at attention two feet in rear of No. 3, facing in the same direction. At the command "**MOUNT**" the gunner and No. 1 mount as prescribed (3-inch Gun Matériel). Nos. 4 and 5 mount as prescribed (3-inch Gun Matériel, caisson model of 1916). No. 6, as soon as Nos. 4 and 5 have taken their seats, places his right foot at the junction of the trail and the footboard of the caisson and grasps the chest handle with his left hand, a grip strap with his right. He then mounts, turning to the right about, and seats himself between Nos. 4 and 5. No. 7, as soon as Nos. 2 and 3 have seated themselves, places his left foot on the step, grasps the chest handle with his left hand. He then mounts, placing his right foot on the limber chest between Nos. 2 and 3, and steps down on the footboard, seating himself between the two cannoneers. Nos. 6 and 7 should not start to mount until the cannoneers they mount between have seated themselves.

If the limber (model of 1917—British) is used at the command "**Cannoneers prepare to mount,**" the gunner and No. 1 hasten to the rear of the piece limber. They grasp the guard rails (chest handles) with the hand nearest the wheel, place the foot farthest from the wheel on the top of the spade of the piece and grasp hands. Nos. 2 and 3 take the same positions on the caisson limber except that they place the foot farthest from the wheels on the futchel (middle rail). At the command "**MOUNT**" all cannoneers spring up, the gunner, Nos. 1, 2, and 3, place the foot nearest the wheel on the chest and step down on the footboard. No. 7 mounts in the same manner as No. 3 did, stepping down and seating himself between Nos. 2 and 3.

To dismount the cannoneers. Instruction Memorandum No. 12 (Notes—3d hour, 1st week).

At the command "**Prepare to dismount**" all cannoneers stand up on the footboards, unfolding their arms. At the command "**DISMOUNT**" all cannoneers jump to the ground and hasten to their posts. Nos. 3 and 7 jump down on the left of the trail, No. 3 being careful to jump far enough away from the pole in order to leave room for No. 7. Nos. 4 and 6 jump to the ground on the right of the trail, No. 4 being careful to jump far enough away from the trail in order to leave room for No. 5. Most of the period should be devoted to instruction in the above movements.

If any time remains, the instructor should review the movements

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below. This review should be in the nature of a drill. The movements should not have to be explained to the cannoneers.

To form the gun squads (170–173).
To tell off the gun squads (174).
Posts of the gun squads, carriages limbered (175–177).
To leave the park (204).
To post the gun squads (178–179).
To move by hand the carriages limbered (191–192).

2d Hour. Paragraphs 193–198.

Equipment: Four gun sections—British 75mm. Matériel (caisson model of 1916).

Review disposition of the carriages before unlimbering. It is not necessary to explain this to the candidates as it has been covered thoroughly before. Merely review it as part of the practical work.

Review: To unlimber—general rules. It is not necessary to explain this to the candidates as it has been covered thoroughly before. Merely review it as part of the practical work.

Action front should be executed as prescribed for the 3-inch Gun Matériel (caisson model of 1916) with the exception that No. 2 runs directly to the wheel that is to become the right wheel of the piece passing between the piece and the caisson. No. 3 runs around the rear of the caisson and muzzle of the piece to the wheel that is to become the left wheel of the piece.

The disposition of the carriages after unlimbering is the same as prescribed for the 3-inch Gun Matériel (caisson model of 1916). The trail of the caisson points to the rear.

The posts of the cannoneers, carriages unlimbered but not prepared for action, are the same as prescribed for the 3-inch Gun Matériel (caisson model of 1916).

Limber front and rear should be executed as prescribed for the 3-inch Gun Matériel (caisson model of 1916) with the following exceptions. In limbering Nos. 2 and 3 assist at the wheels of the caisson. No. 2 at the right wheel, No. 3 at the left. Nos. 6 and 7 assist at the wheels of the piece. No. 6 at the left wheel, No. 7 at the right. In order for No. 3 to get to his proper post, as soon as the gunner has given the command "Limber halt," No. 3 jumps over the trail of the piece and hastens to the left wheel of the caisson. In order for No.7 to get to his proper post, as soon as the command "Limber halt" has been given by No. 4, No. 7 jumps the trail and hastens to the right wheel of the piece.

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3d Hour.

Equipment: Four gun sections (3-inch Matériel); 4 panoramic sights (model of 1904); 4 quadrants; 8 drill cartridges.

Review: Direct laying; Indirect laying; Kinds of fire; Salvo fire; Volley fire; Reciprocal laying.

The instructor should emphasize particularly the following points: Accuracy in the setting of scales; the taking up all lost motion as prescribed; accuracy in laying the piece; accuracy in centering bubbles; accuracy in setting fuses. The gun squads should not attempt to get speed at first. This should be acquired gradually. All the above points are necessary for a good firing battery and this should be kept in view by the instructor so that the squads will progress each day.

4th Hour.

Equipment: Four gun sections—British 75mm. Matériel (caisson model of 1916).

To move by hand the carriages unlimbered is executed as prescribed for the 3-inch Gun Matériel (caisson model of 1916). It is not necessary to explain this movement to the candidates as it has been covered thoroughly before. Merely review it as part of the practical work.

Action rear is executed as prescribed for the 3-inch Gun Matériel (caisson model of 1916). Merely review this movement as part of the practical work.

Limber rear is executed as prescribed for the 3-inch Gun Matériel (caisson model of 1916) with the following exceptions: In limbering Nos. 2 and 3 assist at the wheels of the caisson, No. 2 at the right wheel, No. 3 at the left (facing in the direction which the trail points). Nos. 6 and 7 assist at the wheels of the piece. No. 6 at the left wheel, No. 7 at the right. In order for No. 3 to get to his post, as soon as the gunner has given the command "Limber halt," No. 3 jumps across the trail of the piece and hastens to the left wheel of the caisson (facing in the direction in which the trail points). At the same command No. 2 hastens to his post. In order for No. 7 to get to his position as soon as No. 4 has called "Limber halt," No. 7 runs around the end of the pole of the piece limber or around the lead pair, and hastens to the right wheel of the piece. At this same command No. 6 runs to his post. Nos. 2 and 3 perform the duties of No. 6 and 7 respectively, when they are not present.

Action right (left) is executed as prescribed for the 3-inch Gun Matériel (caisson model of 1916). Merely review this movement as part of the practical work.

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5th Hour.

Equipment: Four gun sections—British 75mm. Matériel (caisson model of 1916); 2 panoramic sights (model of 1904); 2 panoramic sights (model of 1915); 4 drill cartridges—75mm.

The **method** of instruction for "Prepare for action" and "March Order" should be the same as prescribed for the 3-inch Gun Matériel. The gunner and No. 1 step inside the brake arms. The gunner assists No. 1 in removing the breech cover. The instructor should have No. 1 perform this duty now. The straps connecting the breech and muzzle covers should be unfastened so that the gunner and No. 1 start at the top and work down. The gunner unbuckles all the straps on the left of the center of the piece; No. 1 unfastens them on the right. After the straps have been unbuckled, the gunner removes the breech cover and throws it over on top of the caisson chest. He then opens the sight box with his left hand, presses down the spring catch on the top of the box with the thumb of the same hand, and grasps the sight at the shank with his right hand, back of the hand up, thumb pointing to the **rear.** He slides the sight to the rear and removes it from the box. He then turns the sight to an upright position and places it in its seat in the sight carrier (sight shank) and clamps it. He sets the deflection at zero. With his left hand he grasps the traversing screw (peep sight screw) and sets the deflection of the rocking bar sight (peep sight) at zero. With his left hand he grasps the micrometer disc of the angle of sight device and sets the site at 300, being careful to always place his eyes so that he can look squarely at the scale. With his left hand he grasps the lower elevating handwheel and levels the bubble. The instructor should explain that the handle on the wheel, starting at the top, moves in the **opposite** direction to that in which the bubble moves. The last movement of the breech should be up. In order to do this the last movement of the handwheel should be toward the gunner, handle starting at the top (clockwise). The gunner assists No. 1 to raise the top shield. He grasps the handle of the locking bolt with his left hand and pulls it out as far as it will go. No. 1 grasps the locking bolt on the right with his right hand and pulls it out in the same manner. The gunner, using his right hand, and No. 1, using his left, raise the top shield. The locking bolts are then pushed home. The gunner equips himself with a lanyard. The lanyard is kept in the tool box on the right and the gunner should get the lanyard from No. 1. As soon as the gunner has received the lanyard he takes his seat and assumes his proper position, which will be explained later—"Posts of the cannoneers carriages unlimbered and prepared for action."

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No. 1 has already completed his first duty, that of removing the breech cover, but the instructor should mention this so that it will appear in its proper order. No. 1, after unbuckling the straps on the breech cover, releases the elevating lock by pushing it forward with his left hand. He grasps the upper elevating handwheel with his right hand, back of his hand to the rear, and sets the range at 3000. The range drum is divided into mils and meters, the meter divisions being marked on the right side of the wheel. The least reading is 50 meters. No. 1 should be careful to place his eyes opposite the index so that he can set the scales accurately. In order to take up any lost motion the upper elevating handwheel should be turned toward No. 1, the handle starting at the top (counter clockwise). He grasps the locking pin of the traversing clamp with his right hand and the traversing clamp with his left, back of the hand up. He removes the locking pin and pushes the clamp away from him as far as it will go. He grasps the apron latch with his left hand and the locking pin with his right. He removes the pin and releases the apron by pulling up on the latch. No. 1 has already assisted the gunner in raising the top shield but the instructor should mention it now so that it will appear in its proper order. No. 1 grasps the hand lever (operating lever) with his left hand, compresses the hand lever retaining catch (lever latch), and opens the breech by pulling toward him. He examines the bore and chamber, cleaning any parts which require it. He seats himself on the right trail seat. His exact position (carriages unlimbered and prepared for action) will be described later.

No. 2 runs around the right of the piece and removes the muzzle cover, waiting if necessary for the gunner and No. 1 to unbuckle the connecting straps. No. 2 places the cover on top of the caisson chest. He removes the cover from the fore sight (front sight). He runs around to the trail and turns back the traversing lever (trail handspike) and engages it. This is done by pushing down on the lever until it stops. The automatic catch should snap and the lever will be locked. He distributes tow or waste to the cannoneers for use in their ears and seats himself astride the traversing lever (trail handspike). His exact position will be described later in "Posts of the cannoneers, carriages unlimbered and prepared for action."

No. 3 removes the cover from the fuse setter and if it is not fastened, places it on top of the caisson chest. While he is doing this he should stand out of the way of No. 4, who, assisted by No. 5, should lower the caisson apron. After Nos. 4 and 5 have completed this, No. 3 lowers the fuse setter. From now on the duties of No. 3 are the same as prescribed for the 3-inch Gun Matériel.

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No. 4 has already assisted No. 5 to lower the caisson apron but the instructor should mention this in order that it may appear in its proper order. No. 4 assisted by No. 5 raises the caisson door and takes his place ready to serve ammunition.

No. 5 has completed his first two duties. He now removes a round of shrapnel from the chest, places it in the fuse setter, and sets the fuse. He stands ready to serve ammunition. As soon as all cannoneers have completed their duties the chief of section reports his section in order as prescribed for the 3-inch Gun Matériel.

Posts of the cannoneers, carriages unlimbered and prepared for action:

The posts of the cannoneers, carriages unlimbered and prepared for action, are as prescribed for the 3-inch Gun Matériel (caisson model of 1916) with the following exceptions: The gunner is seated on the left trail seat, both legs in front of the brake arm, his right knee on the right of the traversing handwheel. He should lean against the shoulder guard, placing the upper part of his arm just above the elbow in the curved part of the guard. His right forearm should be horizontal and should rest on the right thigh. He should grasp the lower elevating handwheel with his left hand, back of the hand up.

No. 1 is seated on the left trail seat, both legs in front of the brake arm. He should grasp the hand lever (operating lever) with his left hand. His right forearm should be resting on his right thigh.

No. 2 should sit astride the traversing lever (trail handspike) with his feet on the ground. He grasps the lever with both hands in front of him.

The methods of instructing the candidates in execution of "March Order" is the same as prescribed for the 3-inch Gun Matériel. The instructor should impress upon the cannoneers that the duties in "March Order" are not executed in the reverse order from the way they were in "Prepare for action" in the cases of the gunner and No. 1.

The gunner first lowers and secures the top shield with the assistance of No. 1, locking and unlocking the locking bolts as prescribed in "Prepare for action." He sets the deflection of the panoramic sight at zero, unlocks it, and grasps it at the shank, with his right hand, back of the hand to the right rear. He removes it from its seat in the carrier (sight shank), turns the back of his hand up, head of the sight pointing toward him, the T lug pointing down. He opens the sight box with his left hand and presses down on the

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spring catch. He then places the sight in its seat on the box cover by engaging the T lug and pushing forward. He closes the box and secures it. He returns the lanyard to No. 1 who places it in the tool box. He assists No. 1 to put on the breech cover. He should remove it from the caisson and wait until No. 1 has arrived at the particular duty.

No. 1 has already assisted the gunner to lower the top shield but the instructor should mention it so that it shall appear in its proper order. No. 1 closes the breech. He reaches down with his right hand, grasps the apron on the side and raises it, until the apron latch has locked and secured it. He inserts the locking pin with his right hand. He grasps the traversing clamp with his left hand, back of the hand up, and the locking pin with his right hand. He pulls the clamp toward him as far as it will go and places the locking pin in its seat.

He depresses the breech as far as it will go by turning the upper elevating handle with his right hand, back of the hand to the front. He then pulls the elevating lock backward as far as it will go, thus securing it. He now assists the gunner to put on the breech cover. The gunner, before starting to put it on the breech, should see that he has it properly placed. He should hold it so that the three leather rings are on the left with the slit for the shoulder guard below them and the single leather ring on the right. After it has been placed over the breech, the gunner and No. 1, starting at the top, buckle all the straps.

No. 2 places his right foot on the pawl stud and releases the catch which locks the traversing lever (trail handspike). He then turns back and secures the lever. He runs around the right of the piece and puts the cover on the fore sight (front sight). He removes the muzzle cover from the caisson and places it on the gun. He runs around the right of the piece to his post.

No. 3 sees that the fuse of any round whose fuse has been set is set back to safety. He then sets his scales at corrector 30 and range 3000. He raises and secures the fuse setter **from his position on the ground.** He rises and gets out of the way of No. 4.

No. 4 assists in setting the fuse back to safety. He passes the round to No. 5 who places it in the chest. Assisted by No. 5, No. 4 lowers the caisson door and secures it. They then raise and secure the caisson apron as prescribed for the 3-inch Gun Matériel. No. 3 places the cover on the fuse setter and secures it.

All cannoneers, as soon as they have completed their duties, take their posts and the chief of section faces the executive and reports "No. 1 in order, sir," etc.

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6th Hour.

Equipment: Four guns—British 75 mm. Gun Matériel. Four panoramic sights (model of 1915).

Duties in detail of the gunner.

The methods of instruction used are the same as prescribed for the 3-inch Gun Matériel. Have the cannoneers memorize the duties of the gunner in the service of the piece which are:

1. To set and release the brake.
2. To set the deflection.
3. To apply the deflection difference.
4. To set the site and level the bubble.
5. To give the direction to the piece.
6. To bring the line of site on the target in direct laying.
7. To call "Ready."
8. To move his head out of the way before the piece is fired.
9. To fire the piece.
10. To measure the deflection.
11. To measure the site.

Give the commands for indirect laying and have each cannoneer go through one problem. As soon as the aiming point has been identified by the gunner, he reports "Aiming point identified." Have them line up in four columns in rear of the gunners' seats, one column at each gun. Explain indirect laying first. Although the first duty of the gunner is to set and release the brake it might not necessarily come in that order. Consequently the gunner releases the brake whenever a movement of the trail is neeessary and sets it again when the movement is completed. To set the brake the gunner grasps the brake lever (brake handle) with his left hand, back of the hand up, throws it forward until the brake shoes come firmly against the wheel. To release the brake the gunner grasps the quick release lever with his left hand and withdraws it until the brake shoes clear the wheels. The gunner sets the deflection and applies the deflection difference as prescribed for the 3-inch Gun Matériel. The gunner grasps the micrometer disc of the angle of site device with the thumb and forefinger of his left hand, back of the hand to the rear, and sets the site prescribed. The last movement of the micrometer disc should be to the left (counter clockwise) in order to take up the lost motion. He grasps the lower elevating handwheel with his left hand and levels the bubble. He should always be careful to look squarely down on the bubble while setting it and to take up the lost motion as prescribed. He grasps the traversing handwheel with the right hand, back of the hand to the

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rear, and lays the vertical hair of the panoramic sight on the aiming point. The last movement of the traversing handwheel should be away from the gunner, and starting at the top (counter clockwise). As soon as No. 1 has called "Set" and the gunner has laid the piece, he grasps the firing handle with his right hand, back of the hand to the right, and reports "Ready." He sits up in his seat and keeps his eyes on the executive. His left hand rests on his left knee. At the command "Fire" of the executive the gunner pulls the firing lever (firing handle) toward him **smartly** and **releases** it quickly. If the lanyard is to be used the chief of section cautions "With the lanyard" as soon as all the data has been given by the executive. As soon as the gunner has laid the piece and after No. 1 has called "Set" he hooks the lanyard to the firing lever (firing handle) and reports "Ready." All cannoneers then stand clear of the wheels but keep down under cover as much as possible. The gunner grasps the lanyard in his right hand, the rope coming out between the first and second fingers. At the command "Fire" of the executive he pulls the lanyard smartly to the rear. The aiming point and deflection should be so chosen that no movement of the trail will be necessary. The instructor should verify the settings and check to see that the vertical hair of the panoramic sight is laid on the aiming point. After all the cannoneers have had a problem in indirect laying, the instructor should explain direct laying, giving one problem to each cannoneer as before. As soon as the gunner identifies the target after it is announced he reports "Target identified." The gunner sets the brake after the piece has been given its general direction. He then sets the deflection on the panoramic sight. He lays the vertical hair of the sight on the center and the horizontal hair at the bottom of the target. He manipulates the elevating and traversing devices at the same time. The remaining duties of the gunner are the same as before. The instructor should check all settings and see that the gun is laid accurately on the target. The graduations on the deflection scale of the rocking bar sight (peep sight) correspond to those on the panoramic sight, the unit of scale being one mil. Toward the left the readings increase, the maximum reading being 90 mils. In order to move the sight in this direction the traversing screw (peep sight screw) is turned away from the gunner, thumb starting at the top (counter clockwise). Toward the right the readings decrease, the minimum reading being 6310. The sight is moved in this direction by turning the traversing screw (peep sight screw) toward the gunner. The last movement of the traversing screw (peep sight screw) should be away from the gunner, thumb starting on top (counter clockwise).

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The upper front window in the shield is 250 mils wide so that a target or aiming point which has a deflection between 125 mils and 6275 mils can be seen without raising the sight carrier (sight shank) and lowering the top shield.

The gunner measures a deflection as prescribed for the 3-inch Gun Matériel. It should not be reviewed at this point.

The instructor should explain how to measure the site. The instructor commands "Target ——, measure the site." The gunner traverses and elevates the piece until the line of sight is directed upon the bottom of the target. He then levels the bubble in the angle of site device by turning the micrometer disc. He reads the site and calls out "Site ——." The instructor should take time here to call the attention of the cannoneers to the fact that no range is set off in the operation as is done when No. 1 measures the site using the 3-inch Gun Matériel. This is due, of course, to the fact that the angle of site device and line of sight are on the same elevating device and are not affected by any range settings at all (the independent line of sight). If time permits the instructor should give each cannoneer a problem in measuring the site. This should be postponed to the last of the hour until after the duties of No. 1 and No. 2 have been taken up.

Have the cannoneer memorize the duties of No. 1 in the service of the piece which are as follows:

1. To adjust the brake.
2. To open the breech.
3. To set the range.
4. To close the breech.
5. To call "Set."

It is not necessary to give any problems involving **only** the duties of No. 1. The instructor should explain them. After the gunner has set the brake the first time, No. 1 turns the adjusting screw with both hands until the brake shoes set firmly against the wheel. Thereafter the quick release device, operated by the gunner, serves to set and release the brake. No. 1 opens the breech as prescribed in "March Order." No. 1 grasps the upper elevating handwheel with his right hand, back of his hand to the rear, and sets the range, being careful to look **squarely** at the index so as to get an exact setting. No. 1 closes the breech as soon as a round has been inserted. He closes it as prescribed for the 3-inch Gun Matériel (Par. 884, D. and S. R. F. A.). After the above duties have been performed he calls "Set" and grasps the tensile stay with his left hand being careful to keep clear of the breech.

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The duties of No. 2 are exactly the same as prescribed for the 3-inch Gun Matériel. The width of the trail spade is 220 mils.

If time permits, give each cannoneer a problem in measuring the site.

7th Hour.

Equipment: Four gun sections—British 75 mm. Gun Matériel. Four panoramic sights (model of 1904); 8 drill cartridges—75 mm.

Drill the cannoneers as a firing battery. At first the instructor should have the cannoneers perform their duties very slowly. He should pay particular attention to details.

At the command "Check" by the instructor, the chiefs of sections read off in rotation the data given below. In indirect laying the chief of section checks and reports as follows: "Deflection ——, on (off) aiming point, site ——, bubbles (not) level." He then steps across the trail and reads the range on the range drum and reports, for instance, "Three two hundred." He then checks and reports on the data set on the fuse setter as prescribed for the 3-inch Gun Matériel. In direct laying the chief of section checks and reports as follows: "Deflection ——, on (off) target)." The remaining data is checked and reported on as in indirect laying.

Review: Salvo fire. After the command "Fire" has been given by the executive the gunners should watch the right arms of the chiefs of sections of the pieces on their right or left, depending on the method of fire. This should be done so that the gunners will know exactly when the adjacent pieces have fired and can judge when to fire their pieces. This can be dispensed with in service firing but must be done at drill because no command "Fire" is given by the gunners.

The illustrations which follow show gun squad drill using the 75 mm. gun carriage, model of 1917 (British) and the caisson model of 1916.

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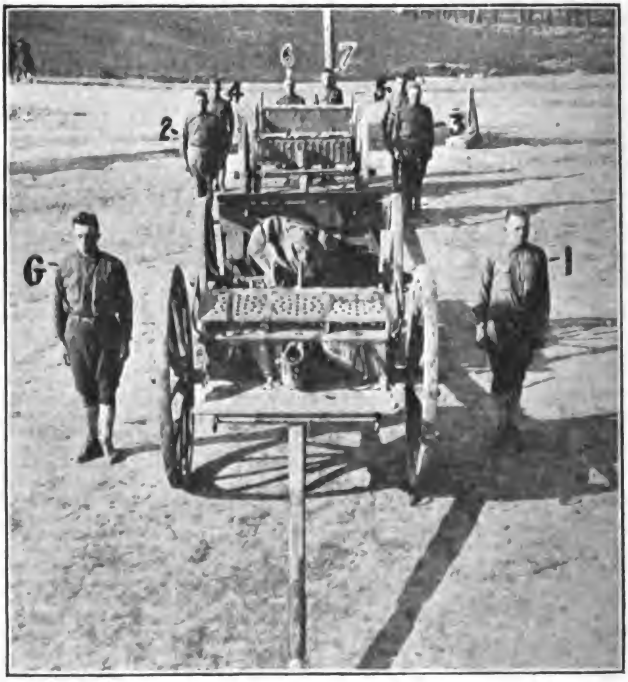

CANNONEERS, POSTS

The gunner repeats the command "Posts" and all cannoneers double time to the positions indicated. Nos. 6 and 7 are one yard in rear of the caisson.

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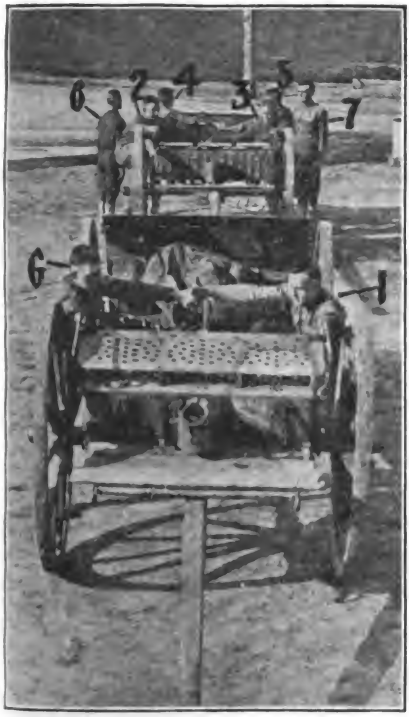
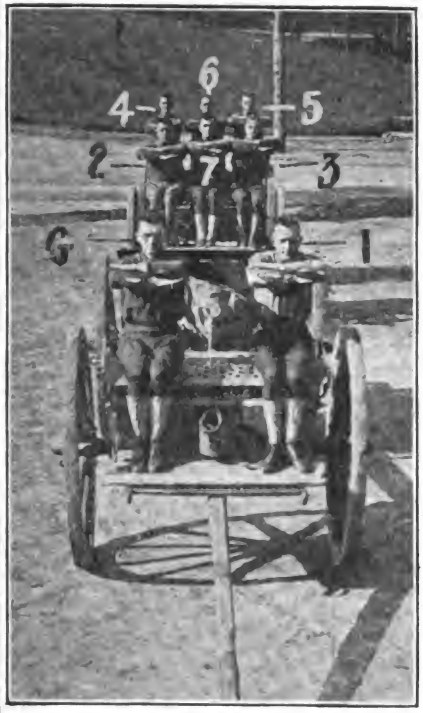


"MOUNT"

This picture shows the cannoneers mounted.

"CANNONEERS, PREPARE TO MOUNT"

At this command the cannoneers take the positions indicated, No. 6 two feet in rear of No. 4; No. 7 two feet in rear of No. 3.



"CANNONEERS, PREPARE TO MOUNT"

(The piece limber)

Illustrating the positions taken by the gunner and No. 1 at the command "Cannoneers, prepare to mount."

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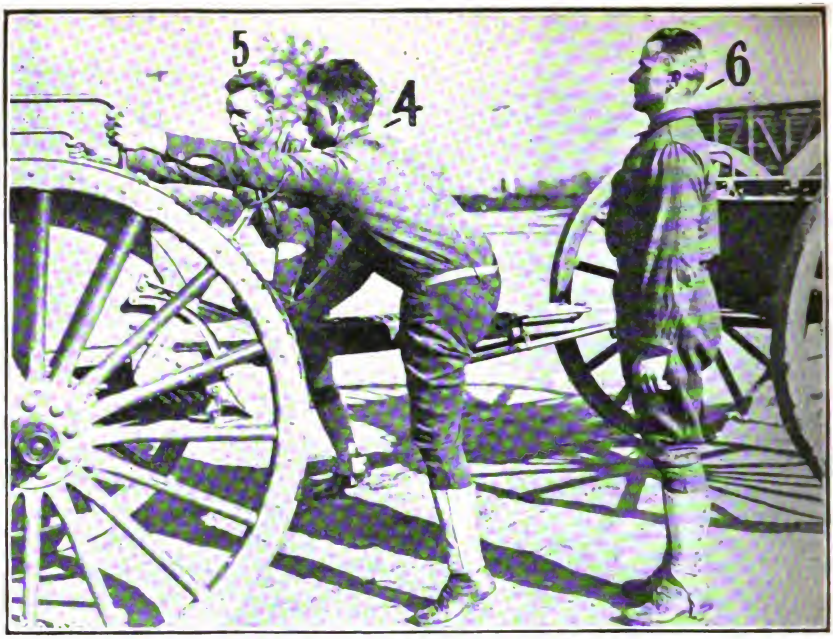
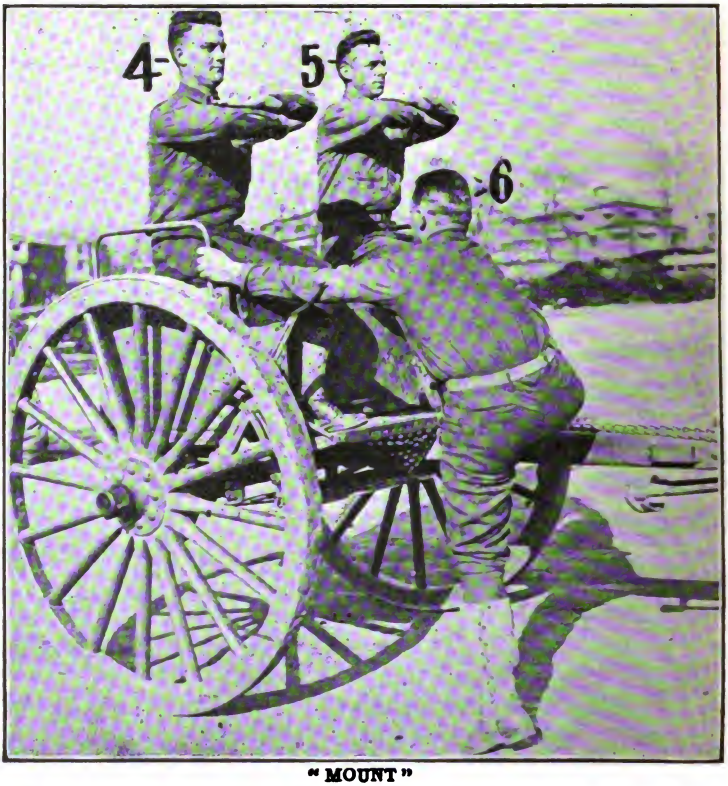


"CANNONEERS, PREPARE TO MOUNT"
(The caisson)

Nos. 4 and 5 grasp the chest handles with the hand nearest the wheel, place the foot farthest from the wheel at the junction of the trail and footboard, and clasp hands, No. 6 runs around the right of the caisson and stands at attention two feet in rear of No. 4, facing in the same direction.



"MOUNT"
(The caisson)

No. 6 mounts after Nos. 4 and 5 have seated themselves, grasping a grip strap with his right hand and the chest rail with his left.

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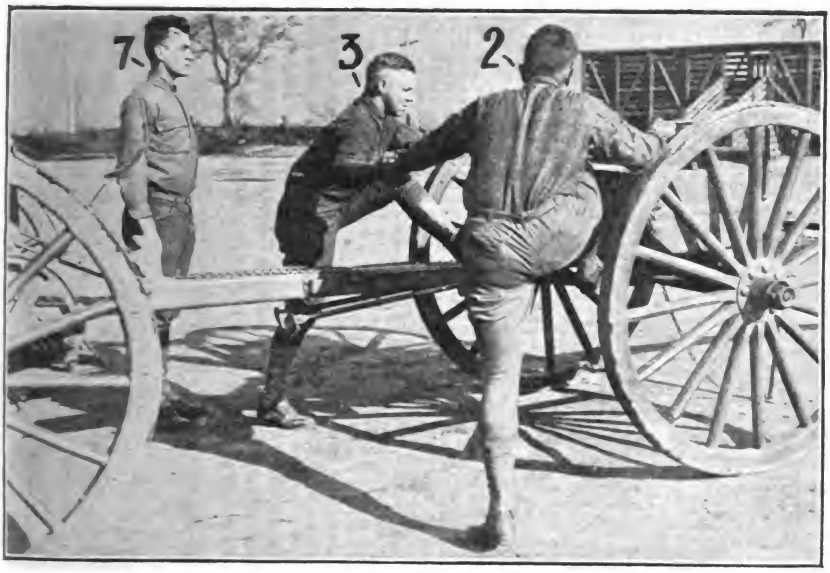

"CANNONEERS, PREPARE TO MOUNT"
(The caisson limber)

No. 7 runs around the left of the caisson and stands at attention two feet in rear of No. 3 facing in the same direction.

"MOUNT"
(The caisson limber)

No. 7 mounts after Nos. 2 and 3 have seated themselves, in the same manner as No. 3, except his right arm is by his side.

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Don't's for Cannoneers

Sometimes the important points of a subject can be better emphasized by telling what not to do. That is the purpose of this list of DON'T'S.

Each cannoneer should learn a new "don't" for each position in the gun squad each day. By putting this into practice, the correct procedure will gradually become a matter of habit and the cannoneer will unconsciously eliminate the more common errors in firing battery drill.

All Cannoneers

Don't
- —Sacrifice accuracy for speed.
- —Guess at the data.
- —Expose yourself.
- —Let your attention be distracted.
- —Make unnecessary moves.
- —Talk.

Chief of Section

Don't
- —Forget that you are responsible for the work of your squad.
- —Fail to assist the gunner in laying on the aiming point.
- —Say "Muzzle right (left)," merely move your hand in the direction you desire the trail shifted.
- —Write down the data.
- —Forget your proper post, covering No. 3 opposite the float.
- —Forget to extend your arm vertically, fingers joined, after the gunner has announced "Ready."
- —Fail to caution "With the lanyard" for the first shot.
- —Fail to look at both the gunner and executive.
- —Command "Fire"; merely drop your arm.
- —Fail to designate who shall assist No. 2 when he is unable to shift the trail.
- —Forget to announce "Volley complete."
- —Forget to select the individual aiming points for the gunner.
- —Forget to announce "No. (so and so), on aiming point," in reciprocal laying.
- —Ever say "Range 3000," merely "3000."

Gunner

Don't
- —Forget to place the sight bracket cover in the left axle seat.
- —Forget to put the sight shank cover in the trail box.

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Gunner—*Continued*

Don't

—Forget to close the panoramic sight box, and fasten it with your left hand.
—Forget to clamp the panoramic sight in its seat.
—Forget to close the ports in the shield.
—Forget to put your weight against the shoulder guard while laying.
—Touch any adjustment after calling "Ready."
—Forget to remove your head from the panoramic sight after calling "Ready."
—Lean against the wheel.
—Fail to take up lost motion in the proper direction.
—Fail to watch the executive after calling "Ready."
—Signal with your hand for movements of the trail.
—Fail to identify aiming points or targets.
—Fail to secure hood on the sight bracket.
—Say "Whoa" to No. 2 while trail is being shifted. Say "Trail down."
—Fail to lower top shield at once at command "March Order."
—Fail to secure all instrument cases.
—Fail to set deflection zero at "March Order."
—Forget to re-lay vertical hair on A. P. at completion of a sweeping volley.
—Forget to set range 1000 deflection zero in "Fire at will."
—Forget to say "Ready" just loud enough for the chief of section to hear.
—Forget to chalk up the deflection on the main shield in reciprocal laying.
—Forget to set site and level bubble (British).
—Forget to release the brake in trail shifts (British).
—Forget to count "1001, 1002" to preserve proper firing interval.

Number 1

Don't

—Touch the firing handle until you announce "Set."
—Fire the piece with the right hand.
—Try to throw the drill cartridge over the float by jerking the breech open.
—Slam the breech.
—Fail to level bubbles.
—Fail to set and release brake in trail shifts.

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Number 1—*Continued*

Don't
- —Fail to look squarely at the scales of the quadrant.
- —Fail to take up lost motion properly.
- —Forget to close the quadrant box.
- —Fire the piece until the command is given.
- —Lean against the wheel.
- —Forget to keep up with the range in direct laying.
- —Forget to lower the top shield immediately at "March Order."
- —Talk.

Number 2

Don't
- —Throw the breech cover on the ground.
- —Fail to engage the hand-spike.
- —Slam the apron.
- —Put feet on the float.
- —Wait for the command in shifts of 50 mils or more.
- —Move the trail in a series of shifts.
- —Fail to mark off 11 lines 50 mils apart at once on taking your post.
- —Fail to secure the breech cover.
- —Fail to secure the hand-spike in "March Order."
- —Run between carriages.
- —Fail to throw empty cartridge cases out of the way of the cannoneers.
- —Forget the tow and waste.
- —Talk.

Number 3

Don't
- —Run between the carriages.
- —Throw the muzzle cover on the ground.
- —Throw the front sight cover on the ground.
- —Slam the apron.
- —Fail to see that fuse is set at safety at "March Order."
- —Fail to look directly down at the fuse setter while adjusting scales.
- —Take right hand from the corrector worm knob and left from the range worm crank, during drill.
- —Forget to set range zero in "Fire at Will."
- —Cross your legs.
- —Forget to set each announced range regardless of the kind of fire being used.
- —Talk.

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Number 4

Don't

—Throw the fuse setter cover on the ground.
—Slam the apron.
—Forget to set the fuse at "Safety" in "March Order."
—Fail to glance into the bore to get the alignment.
—Touch a round after inserting it in the breech.
—Fail to completely set each fuse.
—Forget to take the round from No. 5 from beneath in percussion fire and from the top when the hand fuse setter is used.
—Forget to say, "3200, 2, last round," only loud enough to reach the chief of section.
—Forget to secure the cover on the fuse setter.
—Attempt to move the caisson with the door open.
—Forget to set and release the caisson brake (model 1902).
—Turn the round to the left after setting.
—Talk.

Number 5

Don't

—Slam the apron.
—Attempt to move the caisson with the door open.
—Forget to put your left elbow on the outside of your left knee in using the hand fuse setter.
—Forget to set the brake on the 1916 caisson.
—Throw the water-proof caps under your feet.
—Talk.

A Questionnaire for the Course in Fire Discipline

The sets of questions which follow are arranged to cover the entire course in fire discipline. They are arranged progressively so that the most important points are brought out in proper order. When the student has completed the last set he has covered in logical sequence the whole subject.

First Set.

Assignment for study: D. & S. R. F. A., 938–940, 940–943, 941:

1. (a) Who assists the gunner in raising the top shield?
   (b) At what time is the top shield lowered in executing the command "March Order"?
2. What does No. 1 do at the command "Prepare for Action"?
3. Describe the position of No. 3 at his post, carriages unlimbered, and prepared for action.

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4. What is a lanyard and when is it used?
5. Who assists No. 2 in lowering the piece apron?
6. What does No. 2 do at the command "Prepare for Action"?
7. At what corrector and range does No. 3 set the scales on the fuse setter before receiving any data?
8. Who puts the round in the fuse setter?
9. Who sets the fuse?
10. What does No. 3 do at the command "March Order"?

Second Set.

Assignment for study: D. & S. R. F. A., 955–973, 985–987. 3-inch Handbook, pages 153–164:

1. What is meant by deflection?
2. What is meant by deflection difference?
3. What is meant by the directing piece?
4. At the command "On No. 2 open five," how much does No. 4 open? Does No. 4 increase or decrease the deflection in executing this command?
5. What is meant by direct laying? By indirect laying?
6. Which method is usually used and why?
7. What is the purpose of the panoramic sight?
8. With which hand is the rotating head of the panoramic sight turned?
9. How is the panoramic sight clamped in its seat?
10. (a) On which scale are deflection changes which affect the whole battery set off: such as "Left 90," and "Right 50." (b) Changes which affect only one piece, such as: "No. 2, left 5," "On No. 1 close 10"?

Third Set.

Assignment for study: D. & S. R. F. A., 845–869, 955–956, 969:

1. Who gives the command to fire the piece?
2. How many duties has the gunner in the service of the piece?
3. When the deflection of the piece is increased, which way is the projectile thrown?
4. With which hand does the gunner operate the traversing gear?
5. When does the gunner call "Ready"?
6. At the command "Right 30" what does the gunner do?
7. Under what conditions does the gunner operate the elevating mechanism?
8. What is the eighth duty of the gunner in the service of the piece?

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9. Who calls "Aiming point identified"?
10. Who fires the piece and when?

Fourth Set.

Assignment for study: D. & S. R. F. A., 845–869, 955–956, 969, 973–975; 3-inch Handbook, pages 164–167:

1. What is the function of the range quadrant?
2. Name four principal parts of the quadrant.
3. What is the difference between the range elevation and the site elevation?
4. Which way is the thumb moved to increase the elevation, when operating the scroll gear handle?
5. When a range change of over 500 yards is announced, how is it set off quickly?
6. Which hand operates the micrometer screw?
7. Which way does the range bubble move in relation to the elevation crank handle?
8. What does 300 on the level micrometer disc represent?
9. What should the readings be on the range disc and the level micrometer disc before any data is set down?
10. Why is 300 chosen as a horizontal?

Fifth Set.

Assignment for study: D. & S. R. F. A., 870–891, 845:

1. What is the first duty of No. 1?
2. When does No. 1 open the breech?
3. What is the position of No. 1's elbow, breech open?
4. (a) With which hand does No. 1 set the site?
   (b) Range?
5. When does No. 1 call "Set"?
6. What is No. 1's first duty when the command "March Order" is given?
7. In which kind of laying does No. 1 not operate the elevating mechanism?
8. When does No. 1 use the lanyard?
9. By whose command does No. 1 fire the piece?
10. Describe No. 1's position, carriage prepared for action.

Sixth Set.

Assignment for study: D. & S. R. F. A., 892–901:

1. What is the width of the spade in mils? Of the float?
2. What should No. 2 do immediately after performing his duties in "Prepare for action" to aid him in estimating a shift of 50 mils or more?

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3. When does No. 2 shift the trail without command?

4. When does No. 2 take the ejected shell? What position does he take?

5. At whose command does No. 2 shift the trail?

6. In what methods of fire is it especially important that the gunner and No. 2 work together?

7. Duties of No. 1 in the service of the piece?

8. When does No. 1 release the brake? When does he set it?

9. What is the position of No. 1 at the piece before he calls "Set"? After?

10. With which hand does No. 1 set the range?

Seventh Set.

Assignment for study: D. & S. R. F. A., 870–891, 892–901, 980–984. 3-inch Handbook, pages 53–58; 75 mm. Br. Matériel Book, pages 27–29:

1. What are the duties of No. 1 in direct laying?

2. What position should No. 1 take after he calls "Set"?

3. How should No. 2 shift the trail?

4. How does the gunner indicate that he wishes the trail shifted?

5. How does No. 1 measure the sight?

6. In measuring the site, why is any **convenient** range set on both the quadrant and the sight shank?

7. Name the principal parts of the quadrant.

8. Of what use is the cross-level bubble?

9. What is the purpose of the corrector?

10. Why does raising the corrector raise the height of burst?

Eighth Set.

Assignment for study: D. & S. R. F. A., 901–912, 870–891, 892–901:

1. When is the fuse set at safety and how is this accomplished?

2. Name the principal parts of the hand fuse setter, model 1912—model of 1905M.

3. Of what use is the pointer arm on the 1912 model fuse setter?

4. Which way does No. 3 turn the corrector worm knob to increase the setting? the range worm crank?

5. Which hand does No. 1 use to set the site? the range?

6. State the rule by which No. 1 knows in which direction to turn the elevating crank to level the range bubble.

7. When does No. 1 call "Set"? What is his position at the gun before he calls "Set"?

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8. How does No. 1 fire the piece with the lanyard?

9. In which direction should be the last movement of the elevating handle?

10. Name the duties of No. 3 in the service of the piece.

Ninth Set.

Assignment for study: D. & S. R. F. A., 901–912, 944–946, 947–951, 1025–1032, 995–1002:

1. How is the corrector scale divided? the range ring?

2. Why is the corrector set at 30 at "Prepare for action" and "March Order"?

3. How does No. 3 set the scales on the hand fuse setter? What position does he take?

4. Why does No. 3 call "Cut"? When?

5. What is the function of the stop on a drill cartridge? What is the function of the rotating pin notch?

6. You are No. 3, firing on the range; the piece is being loaded with shrapnel; "March Order" is given. What would you set on the fuse setter scales?

7. Who has charge of the replacement of casualties? Of ammunition?

8. What are the duties of a chief of section in the firing battery?

9. What are some of the things done at once after a battery goes into position?

10. At the command, "Right left," which piece fires first? "Left left" and "Left right"?

Tenth Set.

Assignment for study: D. &. S. R. F. A., 912–919, 919–924, 870–891, 892–901, 980–984:

1. What is salvo fire?

2. You are No. 1 of the 4th piece and the following data comes down: "Corrector 26, Right right, 2600." What would you do?

3. What is the position of No. 4 at the fuse setter?

4. Describe the movements of No. 4 in the service of the piece.

5. Name the duties of No. 4 in the service of the piece.

Eleventh Set.

Assignment for study: D. & S. R. F. A., 863, 870, 892–901, 902, 912–919, 919–924, 996–1002:

1. What is the first thing that the chief of section does after the deflection difference has been announced?

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2. When does the chief of section report his section in order?
3. During firing, which cannoneers move the caisson?
4. What is done before the caisson is moved during firing?
5. Who reports any part of the matériel out of order and how?

Twelfth Set.

Assignment for study: D. & S. R. F. A., 912–924, 977–984, 1003–1005, 1006–1007:

1. Describe what is meant by salvo fire.
2. Firing battery right, from whom does the gunner on the second piece take his command?
3. What is volley fire?
4. Who catches the first ejected drill cartridge in "Battery 2 Rounds"? the last?
5. Where is the post of the chief of section during firing?

Thirteenth Set.

Assignment for study: D. & S. R. F. A., 1003–1007:

1. In volley fire sweeping, which way does the gunner move the muzzle and how much for each round?
2. In percussion fire with either shell or shrapnel, what does No. 4 do immediately after loading the piece?
3. After the first round of a volley, when does the gunner fire the piece?
4. During percussion fire, does No. 3 keep up with the range according to the commands?
5. Give the duties of the chief of section?

Fourteenth Set.

Assignment for study: D. & S. R. F. A., 1008, 1016–1024:

1. Give the sequence of commands for direct laying.
2. In "Fire at will" when does the gunner give the command "Fire" after the initial round?
3. Give the duties of No. 4 in the service of the piece.
4. Explain briefly the different kinds of projectiles.
5. Does the gunner of the directing piece change his deflection on account of the deflection difference in using the 1915 sight?

Fifteenth Set.

Assignment for study: D. & S. R. F. A., 1008:

1. Where is the post of No. 5, when the hand fuse setter is used (both model caissons)?
2. "Fire at will," what does No. 3 do? What range is set off on the sight shank?

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3. Give the duties of the gunner in the service of the piece.

4. Explain briefly "Fire at will."

5. Give the necessary data for direct laying in the proper sequence.

Sixteenth Set.

Assignment for study: Review:

1. When is "Fire at will" used?

2. In "Fire at will" does the gunner re-lay the piece after each round is fired?

3. After the first round in "Fire at will," at whose command is the piece fired?

4. When the command "Cease firing" is given in "Fire at will," what does No. 4 do?

5. When the command "Fire at will" is given, what does No. 3 do?

6. If No. 1 does not understand what range was announced by the executive, whom does he ask? How?

7. How does volley fire sweeping differ from volley fire?

8. Can volley fire sweeping be used in indirect laying?

9. What is the last thing that the gunner does after he has fired the last round in volley fire sweeping?

10. What does the chief of section do when the volley has been completed?

Seventeenth Set.

Assignment for study: D. & S. R. F. A., 967, 968.

1. How does the gunner know when reciprocal laying is to be employed?

2. What does the gunner of the directing piece do in reciprocal laying?

3. What do the Nos. 2 of the pieces other than the directing piece do?

4. What do the gunners on the pieces other than the directing piece do when their deflections have been announced to them by the directing piece?

5. How do the gunners of the pieces other than the directing piece signify that they have laid their pieces on the directing piece the first time?

6. Why is the operation reciprocal laying verified by repeating the deflection readings a second time?

7. What kind of sheaf is obtained by reciprocal laying?

8. What kind of sheaf is obtained by laying on a high burst?

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9. Are burst readings between zero and 3200 subtracted from A. P. readings?

10. What deflection does the gunner on the piece firing the shot, set off?

Eighteenth Set.

Assignment for study: D. & S. R. F. A., 967, 968:

1. In reciprocal laying, why is it necessary for each gun to pick an individual aiming point after the guns have been laid?

2. Who selects the aiming point for the guns other than the directing piece?

3. What does the chief of section do when his piece has been laid on its new aiming point?

4. When does the gunner chalk up the deflection on the main shield?

5. How is the accuracy of reciprocal laying checked?

6. What is the normal interval between adjacent pieces?

7. How should the guns be laid before attempting to lay on a high burst?

8. What is the purpose of laying on a high burst?

9. After laying on a high burst, does each piece lay on an individual aiming point?

10. When the command is given to lay on a high burst, what do the gunners on other than the directing piece do first?

Nineteenth Set.

Assignment for study: D. & S. R. F. A., 1012–1015, 1033–1043:

1. What method of fire is used in firing at a moving target?

2. In which direction does the gunner traverse the piece after setting the data, firing at a moving target?

3. Does the gunner traverse the piece to the center, when No. 2 shifts the trail, firing at a moving target?

4. When the gunner has traversed the gun to the limit in following the moving target and gives the proper command, how far does No. 2 shift the trail?

5. After the piece is fired at a moving target, what does the gunner do?

6. If the target disappears behind an obstruction, what does the gunner do?

7. Why is deflection set off in firing at a moving target?

8. Why is it very important that No. 2 should perform his duties accurately in firing at a moving target?

9. Does No. 1 wait for the command "Fire," when firing at a moving target?

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10. After the first round, who gives the command "Fire," when firing at a moving target?

Twentieth Set.

Assignment for study: D. & S. R. F. A., 1012–1015:

1. From what supply is the ammunition of the gun sections ordinarily replenished?
2. Under what conditions is the ammunition from the limbers of the firing battery used?
3. What officer has charge of the replacement of casualties?
4. In the event of an officer being wounded, by whom is he replaced?
5. If No. 2 is killed, who performs his duties?
6. What is the least number of men required to keep a piece in action?
7. If all cannoneers except the gunner and No. 1 are killed, how are the duties divided?
8. What men are used for the transfer of ammunition?
9. Is it well to have a large supply of ammunition in dumps in temporary positions?
10. How many men should be in the service of the piece to maintain efficient work?

Twenty-first Set.

Assignment for study: D. & S. R. F. A., Review 995–1002, 1003–1007, 985, 987, 988:

1. What is done at the command "Right left"?
2. When is the command "Fire" given in Salvo Fire?
3. When "Battery 2 rounds" is given what does No. 4 announce as he inserts the second round?
4. What is the command for a platoon volley?
5. How many mils will one turn of the handwheel traverse the piece?
6. What is the last thing the gunner does in volley fire sweeping?
7. Does the gunner give the direction to the piece in direct laying?
8. (a) For what is volley fire particularly suitable?
   (b) For what is salvo fire particularly suitable?
9. When "Left left" is given what do the crews of the first and second pieces do?
10. What is the purpose of volley fire sweeping?

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Twenty-second Set.

Assignment for study: D. & S. R. F. A., 977–984, 1008, 986, 3-inch Handbook, pages 55–58.

1. Name the kinds of fire.
2. What does the gunner do at "Fire at will"?
3. What does No. 3 do at "Fire at will"?
4. Does No. 4 call the number of the round in "Fire at will"?
5. Describe position of No. 3 when hand fuse setters are used.
6. Describe position of No. 5 when hand fuse setter is used.
7. Does gunner re-lay the piece between shots in "Fire at will"?
8. When is "Fire at Will" used?
9. When is indirect laying used?
10. What are commands for various kinds of fire?

Twenty-third Set.

Assignment for study: D. & S. R. F. A., Review 967–968, 985, 987, 988:

1. When is reciprocal laying used?
2. When is laying on a high burst used?
3. What does the Chief of Section report to executive after gunner has finished laying on his own A. P.?
4. What can be said of lines of fire after reciprocal laying?
5. What can be said of lines of fire after laying on a high burst?
6. What is the command for reciprocal laying?
7. When laying on a high burst and reading of burst is 20 and that of aiming point 10, what DF. would gunner set off?
8. What does No. 2 do in reciprocal laying?
9. What happens at "No. (so and so), left 10"?
10. What is setting on elevation index in direct laying, if 1915 panoramic sight is used?

Twenty-fourth Set.

Assignment for study: Review D. & S. R. F. A., 1012–1015, 1033–1043, 986:

1. In firing at a moving target, what does the gunner do?
2. In firing at a moving target, what does No. 2 do at the command "Muzzle Left"?
3. In firing at a moving target, what method of fire is usually used?
4. If the gunner is killed, who takes his place?
5. If No. 4 and No. 5 are killed, who takes their places?
6. Who has charge of the replacement of casualties?

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7. What are the least number of men that can be used to serve a piece?

8. When does executive give command "Fire," when firing at a moving target?

9. How many rounds are fired in "Fire at will"?

10. Who are the most important men in the gun squad?

Twenty-fifth Set.

Assignment for study: Review:

1. At command "Cease firing" in "Fire at will," what does No. 4 do?

2. In volley fire of more than one round who catches the ejected drill cartridge?

3. In percussion fire, when does No. 4 load the piece?

4. What is the position of the chief of section after gunner calls "Ready"?

5. When does No. 1 grasp the firing handle?

6. What does No. 3 do in percussion fire?

7. How does No. 3 take up lost motion in the bracket fuse setter?

8. Who moves caisson during fire? Under whose direction?

9. What does the gunner do after he calls "Ready"?

10. In reciprocal laying with No. 2 the directing piece, the gunner calls "No. 1, 1675," what does gunner on No. 1 do?

Twenty-sixth Set.

Assignment for study: D. & S. R. F. A., Review 1003–1005, 985, 987, 988, 995, 1002:

1. What does No. 2 do after gunner calls "Ready" in a three-round volley?

2. What does No. 4 do as soon as he loads the piece in a two-round volley?

3. Who catches the last drill cartridge in a four-round volley?

4. Does the gunner re-lay the piece between rounds in volley fire of more than one round?

5. Which sight is used in direct laying?

6. Why is a deflection announced in direct laying?

7. Which part of the target is horizontal cross hair laid on in direct laying?

8. Give sequence of data for indirect laying?

9. Give command to fire the right gun of the left platoon first in a platoon salvo.

10. What is the normal interval between shots in a salvo?

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Twenty-seventh Set.

Assignment for study: D. & S. R. F. A., Review 1006–1008, 986, 3-inch Handbook, pages 55–58:

1. What does the gunner do after each round is fired in volley-fire sweeping?

2. What does the gunner do after the last round is fired in volley-fire sweeping?

3. Starting at the top, in which direction is the traversing handwheel turned to throw the muzzle to the left?

4. How many mils does one turn of the traversing handwheel move the muzzle?

5. As soon as the gunner sees A. P. in indirect laying, what does he say?

6. Does the gunner give direction to the piece before he sets the sight in indirect laying?

7. Give the sequence of commands for indirect laying.

8. Explain No. 3's position when using bracket fuse setter.

9. Explain No. 3's position when using hand fuse setter, caisson model 1916.

10. How does No. 5 pass the drill cartridge to No. 4 when using hand fuse setter?

Twenty-eighth Set.

Assignment for study: D. & S. R. F. A., Review 967–968, 985, 987; 988:

1. What is the purpose of reciprocal laying?

2. When is it used?

3. How does gunner of the directing piece announce the deflection to the other pieces?

4. What is the idea of making two readings to each piece?

5. After the piece is laid on the A. P., what does the chief of section announce?

6. After laying on a high burst, what is the relation between the lines of fire?

7. Under what conditions would you lay on a high burst?

8. No. 3 gun fires; Burst readings: No. 1—6200; No. 2—6150; No. 4—450. Aiming point readings: No. 1—3600; No. 2—4800; No. 4—1940. What deflections are set off to lay guns on burst?

9. What does No. 2 do as soon as a target is announced?

10. As soon as a target is announced what does the gunner do?

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Twenty-ninth Set.

Assignment for study: D. & S. R. F. A., Review 1033–1043, 986, 1006–1008, 3-inch Handbook, pages 55, 58:

1. When is "Fire at will" used?
2. At command "Fire at will," what does No. 3 do?
3. At command "Fire at will," what do the gunner and No. 1 do?
4. Where should the projectile burst in "Fire at will"?
5. What kind of ammunition is always used in "Fire at will"? Which sight?
6. When should the gunner fire the piece when "Fire at will" is given?
7. What should No. 4 do after loading the piece in "Fire at will?"
8. Explain how you would set off corrector 32, 4000 on hand fuse setter, model 1905 M.
9. Only gunner and No. 1 are left in a gun squad, how is piece served?
10. Explain how chief of section assists gunner in laying on the aiming point.

Thirtieth Set.

Assignment for study: D. & S. R. F. A., Review 977, 984, 1012–1015, 985, 987, 988:

1. Name the different kinds of fire.
2. What is percussion fire used for?
3. When is time fire used?
4. If a target is moving from right to left, in which direction is the muzzle first moved?
5. When gunner gives a muzzle change in firing at a moving target, what does he do next? How many mils should No. 2 shift the trail?
6. Give the sequence of commands for firing at a moving target.
7. Why is volley fire habitually used in firing at a moving target?
8. Which sight does the gunner use in firing at a moving target?
9. Does No. 1 set range in direct laying?

Thirty-first Set.

Assignment for study: D. & S. R. F. A., 985, 987, 988, preparation for gunners' examination, direct laying:

1. How does the gunner know that direct laying is to be used?

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2. What are the duties of the gunner in direct laying?

3. Does the gunner always bring the piece to the center of traverse in direct laying before shifting trail? If not, when?

4. When is the piece considered laid in direct laying?

5. At what readings should the elevation index and elevation micrometer head be set in direct laying?

Thirty-second Set.

Assignment for study: D. & S. R. F. A., 986; preparation for gunners' examination:

1. What is deflection?

2. How does the gunner set the deflection?

3. Who gives the elevation to the piece in indirect laying?

4. How does the gunner give direction to the piece in indirect laying?

5. Does moving to the left always increase the deflection?

Thirty-third Set.

Assignment for study: D. & S. R. F. A., 986, 987, 988, Direct Laying:

1. How is the peep sight scale graduated?

2. How does the gunner set the deflection on the peep sight?

3. What other sight is used with the peep sight? How should it be adjusted in order to use same?

4. Explain "Fire at will."

5. What is the correct position of the gunner's eye in using the peep sight?

Thirty-fourth Set.

Assignment for study: Preparation for gunners' examination, setting quadrants:

1. How does No. 1 set the site?

2. What is the object of the cross-level bubble? Of the range bubble?

3. How does No. 1 set the range?

4. How does No. 1 give elevation to the piece? When?

5. How does No. 1 measure the site?

Thirty-fifth Set.

Assignment for study: Preparation for gunners' examination, setting fuses (bracket and hand):

1. How is the range scale on the bracket fuse setter graduated?

2. When does No. 3 change the corrector? Give two commands.

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3. How is the corrector scale graduated?
4. How is the lost motion in the range worm taken up?
5. How does No. 3 set off data on a 1905 M hand fuse setter?

Thirty-sixth Set.

Assignment for study: D. & S. R. F. A., 1003–1007, 1006–1008, 177, 184, 986:

1. Volley fire—when does No. 4 load the piece at the command "Battery 3 rounds"?
2. What does No. 2 do immediately after catching the ejected cartridge case?
3. Volley fire—when does the gunner know when to fire?
4. "Battery 3 rounds"—at whose command does No. 1 fire the second and third rounds?
5. In the firing battery, who gives the command "Fire"? When?
6. What is the last thing the gunner does after completing his sweep?
7. What does the chief of section report after a sweeping volley has been completed? To whom?
8. Why is the caisson door closed when it is moved?
9. You are chief of section—your gun fails to fire—what should be done?
10. During the firing a sear is broken. As a chief of section what do you report to the executive?

Thirty-seventh Set.

Assignment for study: D. & S. R. F. A., 996–1003, 1008, 985, 987, 988, 3-inch Handbook, pages 55–58:

1. What elements of the data should the gunner especially listen for in indirect laying? In direct laying?
2. What kind of fire is used in "Fire at will"?
3. Why should the gunner's eye be six inches from the peep sight?
4. Command "Battery Right"—when does the gunner of No. 3 start counting?
5. In case of a misfire of No. 1 when would No. 2 fire in "Battery Right"?
6. Direct laying—at the command "Check Data," who checks? How does he report to the executive?
7. When would you use a hand fuse setter?
8. Direct laying—when does the gunner release the scroll gear to change the range?

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9. Using the panoramic 1916 model (direct laying), why should the gunner be careful to read his elevation scale?

10. Direct laying—what should a good No. 2 do?

Thirty-eighth Set.

1. How does the executive know when the pieces are on their aiming points? What command does he give for reciprocal laying?

2. Why do the pieces on the right of the directing piece add 3200? On the left subtract 3200?

3. When is laying on a high burst employed?

4. In getting a high burst should you increase your site or corrector? Why?

5. Indirect laying—how should the chief of section look along the sight to lay the gunner on the aiming point?

6. What advantages are there in having an aiming point in the rear?

7. You are No. 4—during firing it becomes necessary to move the caisson. What commands would you give?

8. Illustrate the kinds of fire. Methods of fire.

9. "Percussion, Battery Right, 2800"—what does No. 3 set on his corrector scale? On his range scale?

10. Indirect laying—"Deflection 6250 on No. 1 open 15," will the gunner have to lower his top shield to lay on the aiming point?

Thirty-ninth Set.

Assignment for study: D. & S. R. F. A., 1012–1015, 1033–1044, 985, 987, 988:

1. Why is a deflection given in firing at a moving target?

2. If target is moving from right to left should the deflection be between 0 and 15 or between 0 and 6385? From left to right?

3. Should No. 2 shift the trail without command?

4. What is the purpose of No. 2's moving the trail 130 mils in firing at a moving target?

5. When should the executive give the command "Fire" in firing at a moving target?

6. Your gunner is killed, whom would you put in his place?

7. Nos. 4 and 5 are killed. How are their duties distributed?

8. Nos. 2, 3, 4, and 5 are killed. How are their duties distributed?

9. In bringing the horizontal cross hairs on the base of the target, what does the gunner do?

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10. Direct laying is being used. The enemy throws out smoke clouds and screens the target. You are in command of the firing battery and are directing the fire. What would you do?

Fortieth Set.

Assignment for study: Review:

1. One gun crew is destroyed, with the exception of one man: the gun is still in commission. As executive, what would you do?
2. How does a safety officer determine whether or not it is safe to fire?
3. Knowing that your target is on the same level as you are you desire to know the minimum range you can fire at it over an intervening crest behind which you are sheltered. As gunner, what practical means would you take to find it out?
4. What is the position of No. 4 when more than one round is fired?
5. How are Nos. 6 and 7 used in actual war conditions?
6. When checking data in indirect laying, what does the chief of section do?
7. How is the panoramic sight read (model of 1916)?
8. How do you know when to add or subtract the reading on the deflection dial, in reading panoramic sight 1916 model?
9. What are No. 1's duties—direct laying?
10. How do you know when a fuse is properly set, using the bracket fuse setter?

Forty-first Set.

(The subsequent assignments refer entirely to the British Modifications.)

Assignment for study: D. & S. R. F. A., 180, 181–182, 183, 186–187, 170–173, 174, 175; 177, 204, 178–179, 191–192:

1. Give posts of the cannoneers, carriages limbered using British 75 mm. gun.
2. Show by diagram route followed by cannoneers when "Change posts, March" is given, with piece limbered using British 75 mm.
3. Show by diagram route followed by cannoneers when "Gunner and all cannoneers, change posts, March" is given, pieces limbered using British 75 mm.
4. Show by diagram how cannoneers are seated on carriages with British 75 mm. gun using limber model of 1918 British and 3-inch caisson model of 1916.
5. Show by diagram how cannoneers are seated on carriages with British 75 mm. gun using British model of 1917 limber.

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6. Give the direction in which each gunner jumps to the ground when command "Dismount" is given with British 75 mm.

7. Show posts of cannoneers when moving by hand the carriages limbered with British 75 mm.

8. At the command "Action Front," what do Nos. 2 and 3 do when using the British 75 mm.?

9. What are the posts of the cannoneers when the command "Limber front and rear" is given with British 75 mm.?

10. At the command "Limber, Halt" what do Nos. 3 and 7 do in limbering front and rear with British 75 mm.?

Forty-second Set.

Assignment for study: D. & S. R. F. A., 193–195, 196–198 modified; 199 modified, 202 modified:

1. In which direction is lost motion taken up with the elevating handwheel on the 3-inch piece?

2. In what direction is lost motion taken up with the traversing handwheel on the 3-inch piece?

3. In what direction is lost motion taken up with the scales on the bracket fuse setter of the 1905 model?

4. How is lost motion taken care of with the 1912 model bracket fuse setter?

5. How should No. 5 place a projectile in the bracket fuse setter?

6. What are the five points of accuracy that should be observed in the firing battery?

7. In which direction do Nos. 2 and 3 face when the command "Limber rear" is given with British 75 mm.?

8. When Nos. 6 and 7 are not present, who performs their duties when limbering with the British 75 mm.?

9. Explain how the gunner removes the panoramic from its case and places it in its seat with the British 75 mm.

10. In which direction should the last movement of the breech be made when leveling the elevating bubble on the British 75 mm.?

Forty-third Set.

Assignment for study: Prepare for firing battery drill, 3-inch matériel:

1. To what does the rocking bar sight of the British 75 mm. gun correspond on the 3-inch piece?

2. With which hand is the lower elevating handwheel operated on the British 75 mm.?

3. What is the rule for operating the elevating handwheel of the British 75 mm.?

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4. Explain which hand the gunner and No. 1, respectively, use in operating the locking bolts to raise the top shield on the British 75 mm.

5. Where is the lanyard kept on the British 75 mm.?

6. Who removes the breech cover on the British 75 mm.?

7. Where is the breech cover placed when removed from the British 75 mm.? By whom?

8. State which hand is used by No. 1 in setting the range on the British 75 mm. and describe how the handwheel is grasped.

9. By what means is the traversing lock held in place?

10. How is lost motion taken up on the upper elevating handwheel?

Forty-fourth Set.

Assignment for study: D. & S. R. F. A., 937, 200, 203 modified 201:

1. What sort of cover is on the foresight of the British 75 mm.?

2. Describe the position of the gunner with the carriages unlimbered and prepared for action with the British 75 mm.

3. Describe the position of No. 1 with the carriages unlimbered and prepared for action with the British 75 mm.

4. Describe how the gunner returns the panoramic sight to the carrying case in "March Order" with the British 75 mm.

5. Who replaces the lanyard in the tool box on the British 75 mm.?

6. How is the piece apron raised? Who does it?

7. Explain how the traveling clamp is operated and locked.

8. What must No. 1 do immediately before securing the elevating lock on the British 75 mm. in executing "March Order?"

9. How must the cover be placed on the breech before it is buckled?

10. What must No. 2 do before the traversing lever can be released on the British 75 mm.?

Forty-fifth Set.

Assignment for study: D. & S. R. F. A., 938 modified, 941 modified, 942 modified:

1. Where should No. 2 find the muzzle cover of the British 75 mm. in "March Order?"

2. If a fuse has been set and "March Order" is given, what is the next duty of No. 3?

3. Around which side of the piece does No. 2 go in returning to his post after putting on the muzzle cover of the British 75?

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4. Who raises the fuse setter after "March Order" on the British 75 mm.?

5. In what position is the cannoneer who raises the bracket fuse setter after "March Order"?

6. Where does No. 3 place the cover of the fuse setter in "Prepare for Action"?

7. Who sets off the site on the British 75?

8. Who lowers the fuse setter in "Prepare for Action"?

9. How is the range marked off on the range drum?

10. Which cannoneers raise and secure the apron of the caisson?

Forty-sixth Set.

Assignment for study: Duties in Detail of Gunners No. 1 and No. 2 (modified).

1. Give the duties in detail of gunner in the service of the piece.

2. Who fire the British 75 mm.?

3. Describe the position of gunner before announcing "Ready."

4. What is the position of No. 2 in the service of the piece?

5. How is the lanyard attached?

6. What is the meaning of the term "Independent Line of Site?"

7. What are the duties of No. 1 in the service of the piece?

8. What is the width of the trail spade?

9. How is data checked on the British 75 mm.?

10. Describe all the positions of the hands of the gunner in the service of the piece.

Forty-seventh Set.

Assignment for study: D. & S. R. F. A., 996–1002, 1003–1008, 985–988:

1. How does the chief of section announce data at command "Check" (direct and indirect laying)?

2. Who does the gunner watch after the executive commands "Fire" in salvo fire?

3. Who sets off the range in direct laying?

4. What are the duties of the chief of section in the firing battery?

5. What rules does No. 5 observe in placing shells in the fuse setter?

6. Where does No. 5 kneel when using the hand fuse setter with 1916 caisson?

7. In which direction does the gunner turn traversing hand-wheel in volley-fire sweeping? How much?

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8. When does gunner re-lay the piece in volley-fire sweeping?

9. Which way is the last motion of lower and upper elevating handwheels?

10. Which way is the lost motion of the traversing handwheel taken up?

Forty-eighth Set.

Assignment for study: General review of 3-inch Firing Battery:

1. If the reading on deflection dial is small, how does chief of section know when to add or subtract it from the main reading?

2. How many mils are on peep sight scale?

3. What is width in mils of port in top shield? Of the top shield itself?

4. How does No. 1 take up lost motion in the micrometer screw?

5. In reciprocal laying, why is there need of checking the laying by a repetition?

6. What is the value in yards of range of one turn of elevating crank at 3000? At 1500? At 5000?

7. Why is the cross-level bubble used on the quadrant?

8. In volley fire who should hear No. 4 call the number of the round and the range?

9. What is difference between a **method** of fire and a **kind** of fire?

10. If executive commands "Right left," what does he mean?

Forty-ninth Set.

1. Who commands "With the lanyard"? When?

2. If gunner does not know the method of fire, whom does he ask? How?

3. If chief of section finds his piece cannot fire, what does he announce?

4. If a piece is reported out of order, does the executive say anything before commanding "Fire"?

5. Who sets off range in "Fire at will"?

6. Who directs No. 2 after initial data has been announced?

7. Must the chief of section caution the cannoneers to move the caisson? Who takes charge?

8. What are positions of gunner's hands when laying the piece in direct laying?

9. Does No. 1 call "Set" after piece is loaded in volley-fire sweeping?

10. In reciprocal laying who reports when the piece is laid upon its own aiming point?

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Fiftieth Set.

1. Give the position of No. 1's left hand after he has called "Set."
2. Give sequence of commands for volley-fire sweeping.
3. How does No. 2 mark the ground in rear of trail spade?
4. How does the gunner grasp the lower elevating handwheel?
5. Give the duties of the gunner in the service of the piece.
6. When does the executive give the command to fire a volley? A salvo?
7. What is "continuous fire from the right"?
8. When does the captain caution "At my command"? What happens at the guns?
9. Who gives the command to fire the piece at the command "No. 1 only"?
10. What is the position of gunner after announcing "Ready"?

The Gunners' Examination

The Gunners' Examination is the test of the training of the Cannoneer. Anyone who goes through the course of training in Gun Squad Drill and Fire Discipline should take the Gunners' Examination in an effort to qualify as a gunner. Those who succeed in qualifying can feel that they have accomplished that which they set out to do and that they are ready to take up the more advanced work of the Field Artillery.

Accuracy and speed are required in the examination. In instruction, accuracy should be required first and speed will follow.

The subjects of matériel and drill of the gun squad should be covered by a written examination. Only the simplest questions should be given covering the most important points.

Preceding the examination, an instruction period should be given to the preparation of each practical subject. During these periods the instruction should be carried on **exactly** as the examination will be, so that those trying will become used to the methods required by orders.

In the preparation for the Gunners' Examination all should pay particular attention to the following points.

Setting the Panoramic Sight

Before starting to use the panoramic sight, the peep sight should be turned as far as possible to the right or left. This should be done to make it easier for the gunner to look through the panoramic sight and also to prevent him from looking through the peep sight.

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Cannoneers should get into the habit of working from the top of the sight down, performing their duties ALWAYS IN THE SAME ORDER—this is very important. In other words, in **indirect laying,** set the deflection, apply the deflection difference, level the cross-level bubble, and then lay for direction. In **direct laying,** set the deflection, set the range, level the cross-level bubble, and lay the piece for direction and range. In setting the range on the sight shank the gunner should be sure to place his eye **on a level** with the index so that the range can be set exactly. If a range change of over 500 yards is given, the fast motion of the scroll gear should be used. As soon as he has laid his gun he will call "Ready" and step clear of the piece. After he has called "Ready" UNDER NO CIRCUMSTANCES WILL HE ATTEMPT TO FINISH ANY OF HIS DUTIES. If he does he will lose that trial.

All scales should be set rapidly. In order to do this, candidates must not try to make any mathematical calculations. The setting of sights should be **absolutely mechanical.** The gunner should know exactly in what direction to turn the knobs, wheels, and cranks in order to increase or decrease the settings and to move the bubbles in any particular direction. A list of reasons for disqualification is given in the Regulations for the Gunners' Examination.

It is most important in indirect laying that the candidate be assisted by TRAINED chiefs of sections and No. 2's. Candidates should be picked for this during the earlier part of the course and trained for that work. A great deal depends on the ability of these men.

Setting the Peep Sight

In using the peep sight in direct laying the panoramic sight head should be turned to either flank so that there will be no chance of the gunners looking through the panoramic sight. The gunner in looking through the peep sight should keep his eye about six inches from it.

Setting the Quadrant

The candidate should get in the habit of performing the required duties in the following order: (1) Setting the site with his right hand. (2) Setting the range with his left hand as prescribed for No. 1. (3) Centering the cross-level bubble with his right hand. (4) Leveling the range bubble with his right hand. The cannoneer should be sure to look and see where the bubble is before he starts to turn the elevating crank handle. He should turn the handle

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quickly. After leveling the range bubble he calls "Set" and steps clear of the wheels.

Fuse Setting

In setting the bracket fuse setter he should stand immediately in rear of it and should crouch down. The corrector should be set first and the range next, both scales being set with the **right** hand. His assistant should stand immediately to the left and should pass the round to the man who is being examined, as No. 5 passes the round to No. 4 in percussion fire. The candidate, after setting the scales, rises up, grasps the projectile, and inserts it in the fuse setter. He then sets the fuse and calls "Ready." The assistant should hold the projectile so that the lug on the time ring is at 10 o'clock (vertical clockface). The candidate, when he inserts the round in the fuse setter, should place it so that the lug on the time ring falls just to the left of the rotating pin notch. This is done so that the two shall engage as soon as possible.

In setting the fuse with the hand fuse setter, the candidate takes the position prescribed for No. 3 in the service of the piece; his assistant takes the position of No. 5 when the hand fuse setter is used. The cannoneer must be sure to press down on the hand fuse setter while setting the fuse.

Everyone must be cautioned to remember all necessary data. They cannot ask the examining officer for any. It must be impressed on them also that under no circumstances can they start to set the scales before the instant prescribed by the Regulations for the Gunners' Examination.

Drill of the Gun Squad

Candidates should be familiar with the following paragraphs of the D. and S. R. F. A.: Formation of the gun squad (135, 138); to form the gun squad (170–173); to tell off the gun squad (174); post of the gun squads (175–177); to post the gun squad (178–179); post of the cannoneers, carriages limbered (180–182); to mount the cannoneers (183–185); to dismount the cannoneers (186–187); to change posts (189–190); to move by hand the carriages limbered (191–192); to leave the park (204); action front (199); posts of the cannoneers, carriages unlimbered but not prepared for action (188); limber front and rear (202); action rear (200); limber rear (203) to move by hand the carriages unlimbered (937); prepare for action (938); march order (942); posts of the cannoneers, carriages unlimbered and prepared for action (941); duties in detail of the gunner

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(845–869); duties in detail of No. 1 (870–891); duties in detail of No. 2 (892–901); duties in detail of No. 3 (902–911); duties in detail of No. 4 (913–918); duties in detail of No. 5 (919–924); methods of laying (985–988); and methods of fire (995–1008).

The questions will only cover the important points covered in the paragraphs above.

Matériel

Every man should be familiar with the following (Handbook of the 3-inch Matériel). Nomenclature of harness and of the parts and accessories of the wheeled matériel; use of oils; method of cleaning and lubricating parts and mechanisms; method of cleaning cylinder oil and of emptying and filling cylinders; use of tools; the kinds of projectiles, of fuses, and of powder actually issued for use, and their general purpose and effect omitting questions as to construction, weight, manufacture, and technical description; the care and preservation of saddle and harness equipment in use. Description of: breech mechanism, to dismount, to assemble; elevating screws, to dismount, to assemble; hub liner, to remove, to assemble; brakes, piece and caisson, to adjust; wheel, to remove, to replace.

Regulations for the Examination of Gunners

1. Candidates, to be classed as expert first-class gunners, must attain an average of not less than 85 per cent. in each subject prescribed in paragraph 4 of this order; to be classed as first-class gunners, a general average of not less than 85 per cent., with an average in each subject of not less than 75 per cent.; to be classed as second-class gunners, a general average of not less than 75 per cent., with an average in each subject of not less than 65 per cent.

2. Examinations of candidates from batteries will include the following:

Subject	Value of subjects
	Gun batteries
Direct laying	24
Indirect laying	24
Laying for range	18
Fuse setting	18
Drill of the gun squad	8
Matériel	8

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3. The following general rules will govern the boards:

(1) The conditions of examination will be made, as nearly as possible, the same for all of the candidates.

(2) Settings of scales will be considered correct if any part of the index is coincident with any part of the line of graduation of the setting ordered.

(3) Settings ordered will always be even divisions of the scale, and not fractions thereof. When a number greater than five is used, it will be a multiple of five, except in settings of the angle of site and corrector scales.

(4) The candidate may select any of the assistants authorized.

(5) The candidate is permitted to traverse the piece to the middle point of traverse before each trial at direct laying.

(6) The sight, quadrant, or fuse setter, etc., will be in the position in which it would be in service before the command for any trial with it is given; the scales will be set at readings different from those to be given for the trial.

(7) The trials for direct laying will be with different deflections and ranges; for indirect laying with different deflections and deflection differences; for laying for range, with different angles of site and ranges. The trail will be shifted in three trials at direct laying.

(8) Changes in setting of scales required will **not exceed** the following: Deflection scale of peep sight, 15 mils; of panoramic sight, 200 mils; deflection difference scale, 30 mils; corrector scale, 10 mils; angle of site scale, 10 mils; range scales, 800 yards. At direct laying the deflections announced will be between 6370 and 30. At direct laying the cross level of the tangent sight will be thrown out of level by the examiner for the trials requiring shifting of the trail.

(9) In time trails, time will be taken from the word at which the candidate is instructed by this order to commence his trial to the candidate's "Ready," or to the last word of any announcement required. No credits will be allowed if the candidate performs any part of the trial after this interval, or if the time taken exceeds the maximum given in the appropriate table of those shown hereinafter.

(10) Should any trial be vitiated through the fault of an examiner, of an assistant, of the sight or other instrument used, that trial will be void and the candidate will be given immediately another trial of the same nature.

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Direct Laying

Six trials: Three with the peep sight and three with the panoramic sight.

The target will represent a shielded gun and caisson and will be placed, as nearly as practicable, at a distance of 1000 yards from the gun used in the trials.

The candidate being seated on the gunner's seat, an officer of the battery commands, for example:

1. Target, that gun.
2. Deflection, 10.
3. 2400.

At the indication of the target, the candidate causes an assistant at the trail to point the piece in its general direction; **at the last word of the last command** he sets off the deflection and the range ordered; corrects for difference of level of the wheels; operates the elevating and traversing apparatus so as to bring the line of sight upon the target; calls "Ready," and steps clear.

No credits will be given in the following cases:

1. If the sight is incorrectly set for deflection or range.
2. If, when the bubble of the cross level is accurately centered, the line of sight is found not to be on any portion of the target.

If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows:

Time in seconds, exactly, or less than	18	20	22	24	26	28
Credits	4.0	3.0	3.4	3.0	2.8	2.6

Indirect Laying

Four trials.

An aiming point will be selected, toward either the front or the rear. It should be of the type used in actual firing and, for the purpose of this examination, should be about 2 mils in width, well defined, of such height as readily to be brought within the field of view, and about 1500 yards distant. It should be clearly pointed out to the candidates.

All of the guns of the battery will be placed in the order in battery order and a candidate will be assigned to each.

For all trials the board will assume a situation in the conduct of fire for adjustment by battery, commencing with the first salvo, that will require commands involving a shift of the trail for this first

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trial, and, for all trials, such deflection and deflection difference settings and changes of settings of scales, not exceeding the limits prescribed in paragraph 5 of this order, as may reasonably be expected in service.

If the aiming point is in rear the candidate will be allowed an assistant who, from a position in front of the axle, signals to a man at the end of the trail to move it, if necessary, so as to bring the aiming point within the field of view of the sight. If the aiming point is in front, an assistant at the end of the trail is allowed.

The candidates being seated on the gunners' seats, an officer of the battery commands, for example:

1. Aiming point, the chimney on that white house.
2. Deflection, 440.
3. On No. 2 close 10.

At the last word of the command for the deflection each candidate sets off the deflection; applies the correction for deflection difference appropriate for his piece; causes the trail to be shifted until the sight is directed upon the aiming point; corrects for difference of level of the wheels; raises or lowers the panoramic sight until the field of view will include the aiming point; traverses the piece until the vertical hair is on the aiming point; calls "Ready," and steps clear.

The trial being completed and the candidates being again seated, the officer commands, for example, in continuance of the assumed situation:

1. Right 120.
2. On No. 4 close 5.

At the last word of the command for the deflection, each candidate operates the sight and, if necessary, the trail as before; traverses the piece until the vertical hair is on the aiming point; calls "Ready" and steps clear.

The third and fourth trials are similarly conducted.

No credits will be given in the following cases:

1. If the sight is incorrectly set for deflection or deflection difference.
2. If, when the bubble of the cross level is accurately centered the vertical cross hair is found not to be on the aiming point.
3. If, at any time during the trial, the candidate has operated the elevating device.

If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows:

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Time in seconds, exactly or less than	20	22	24	25	26	27
Credits	6.0	5.7	5.1	4.5	4.2	3.9

Laying for Range

Three trials, using the range quadrant.

The candidate being seated on the seat on the right side of the trail, an officer of the battery commands, for example:

1. Site, 280.
2. 3400.

At the last word of the last command, the candidate sets off the angle of site; sets the quadrant for range; corrects for difference of levels of the wheels; turns the elevating crank so as to center the range bubble; calls "Ready," and steps clear.

No credits are given in the following cases:

1. If the quadrant is incorrectly set for example of site or range.
2. If no part of the bubble of the cross level is between the middle two lines on the glass tube.
3. If there be found to be an error of more than 50 yards in laying for any range less than 1500 yards or of more than 25 yards for any range equal to or exceeding 1500 yards.

If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows:

Time in seconds, exactly or less than	16	18	20	21	22	23
Credits	6.0	5.6	5.2	4.8	4.4	4.0

Fuse Setting

Six Trials: 3 with the bracket fuse setter, 3 with the hand fuse setter.

Drill cartridges with fuses in good order set at safety are placed as in service.

An officer of the battery commands, for example:

1. Corrector, 24.
2. 2700.

At the last word of the command for the corrector, in trials with the bracket fuse setter, the candidate sets the fuse setter at the corrector, and, as the data are received, at the range ordered, receives

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the cartridge from an assistant, inserts its head in the instrument, sets the fuse and calls "Cut."

At the last word of the command for the corrector, in trials with the hand fuse setter, the candidate sets the fuse setter at the corrector, and, as the data are received at the range, ordered; with the aid of an assistant, sets the fuse, and calls "Cut"

No credits are given in the following cases:

1. If the fuse setter is incorrectly set for corrector or range.
2. If the candidate fails to obtain a correct fuse setting within one fifth of a second.

If the fuse setter is found to be correctly set and is properly operated, credits are given as follows:

Time in seconds, exactly or less than	10	11	12	13	14	15
Credits	3.0	2.8	2.6	2.4	2.2	2.0

Drill of the Gun Squad

The subjects will embrace such parts of the following exercises (D. and S. R. F. A.) as will thoroughly test the candidate's familiarity with the service of the piece: Formation of the gun squad (135.138); to form the gun squad (170–173); to tell off the gun squad (174); post of the gun squads (175–177); to post the gun squad (178–179); posts of the cannoneers, carriages limbered (180–182); to mount the cannoneers (183–185); to dismount the cannoneers (186–187); to change posts (189–190); to move by hand the carriages limbered (191–192); to leave the park (204); action front (199); posts of the cannoneers, carriages unlimbered but not prepared for action (188); limber front and rear (202); action rear (200); limber rear (203); to move by hand the carriages unlimbered (937); prepare for action (938); march order (942); posts of the cannoneers, carriages unlimbered and prepared for action (941); duties in detail of the gunner (845–869); duties in detail of No. 1 (870–891); duties in detail of No. 2 (892–901); duties in detail of No. 3 (902–911); duties in detail of No. 4 (913–918); duties in detail of No. 5 (919–924); methods of laying (985–988); and methods of fire (995–1008).

The questions will only cover the important parts covered in the paragraphs above.

Matériel

The examination of each cannoneer will be sufficiently extended to test his familiarity with the use and care of the matériel of his

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organization, and will be theoretical. The examination will be conducted by questions on the following subjects: Nomenclature of harness and of the parts and accessories of the wheeled matériel; use of oils; method of cleaning and lubricating parts and mechanisms; method of cleaning cylinder oil and of emptying and filling cylinders; use of tools; the kinds of projectiles, of fuses, and of powder actually issued for use, and their projectiles, of fuses, and of powder actually issued for use, and their general purpose and effect, omitting questions as to construction, weight, manufacture, and technical description; the care and preservation of saddle and harness equipment in use. Description of: breech mechanism, to mount, to assemble; elevating screws, to dismount, to assemble; hub liner, to remove, to assemble; brakes, piece and caisson, to adjust; wheel, to remove, to replace.

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CHAPTER VI

FIELD GUNNERY

THE Field Artillery Officer needs sound knowledge of the fundamental operations of arithmetic, algebra, geometry, and trigonometry.

In arithmetic he should be able to solve with ease and rapidity problems such as the following:

1. A scout trots his horse at the rate of 8 miles per hour and walks at the rate of 4 miles per hour. He is ordered to walk the first five minutes and then trot ten minutes and continue alternating a five-minute walk with a ten-minute trot. The last ten minutes of the hour he rests his horse. What is his rate of travel per hour and when will he finish the third mile? Ans. Five and one third miles per hour. In twenty-seven and one half minutes.
2. In a gun test the muzzle velocities for five shots were 1683.2, 1691.9, 1711.4, 1699.2, and 1706.9 ft. per second. Find the average muzzle velocity. Ans. 1698.5.
3. If in a bombardment 85% of the shots fired at a target fall in the field in which the target is situated, and 49% of these strike the target, what percentage of the shots fired hit the target? Ans. 41.7%

His knowledge of tables of measurement of both English and Metric systems should be such that he can quickly convert a quantity from one system to the other. Problems such as these will be presented for solution:

1. The common shrapnel filling consists of 252 balls, each weighing 167 grains. What is their weight in pounds? Ans. 6.012 pounds.
2. An aeroplane is traveling at the rate of 52 m. per second. Express its speed in km. per hour. Ans. 187.2.

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3. Express the caliber if the 3-inch gun in metric units. Ans. 76.20 mm.
   Express the weight of the 3-inch projectile in metric units. Ans. 6.80 kg.
4. Smokeless powder ignites at about 180 degrees Centigrade. What temperature is this in Fahrenheit? Ans. 356° F.

The following problem illustrates the need of knowing how to find the square roots of numbers.

1. From the battle map it is found that a target lies 2110 m. east and 1560 m. north of the battery. What is the range? Ans. 2624 m.

In algebra the problems here given show the connection the subject has with the work of the Field Artillery Officer.

1. An observer notes the following deviations of shots from the target (angles to the right being called positive): 26 mils, −13 mils, −22 mils, − 19 mils, −24 mils, 0 mils. Find the mean. Ans. $-2\frac{1}{3}$ mils.
2. A horseman took a message to headquarters traveling at the rate of 8 miles per hour. Returning on foot at 4 miles per hour, he was picked up halfway by an automobile traveling at the rate of 25 miles per hour, which delivered him at the starting point 2 hours 20 minutes after his departure. What was the distance to headquarters? Ans. 8.6 miles.
3. At 2400 yards an increase of 1 mil in angle of site increases the range 25 yards. What change in site is necessary to increase to range 40 yards? Ans. Increase 1.6 mils.

Geometry

The commonest problems in gunnery involve the finding of angles formed by more or less complicated systems of lines. In order to solve these problems the student should know thoroughly the basic theorems concerning angles. As a rule the proofs of the theorems will not be required, but ability to use them in practical problems will be demanded.

The angle between two lines, OA and OB, is the amount of rotation about the point O necessary to bring one of the lines into the position of the other. The point O is called the vertex of the angle and the lines OA and OB are the sides. The angle may be

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designated as "the angle AOB" the letter at the vertex being written between the letters on the sides; or as "the angle O"; or a letter

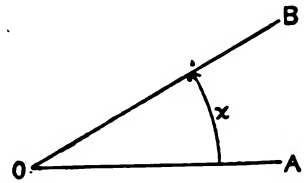

FIG. 1.

within the angle, usually with an arrow connecting the sides, may be used, as "the angle x."

If a circle be drawn with its center at the vertex the magnitude of the angle—that is to say, the amount of the rotation—can be measured by the portion of the circumference lying between the sides.

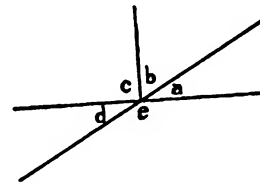

FIG. 2.

The word "angle" is often represented by the symbol ∠. When two lines intersect the opposite, or **vertical,** angles are equal. Thus in Figure 2, ∠a = ∠d.

Angles are called **supplementary** if their sum is two right angles. Thus ∠a and ∠e are supplementary.

Angles are called **complementary** if their sum is one right angle. If in the figure, ∠c is a right angle then ∠a and ∠b are complementary, also ∠b and ∠d are complementary.

An angle smaller than a right angle is called **acute,** as ∠a, ∠b, ∠d, in Figure 2.

An angle greater than a right angle and less than two right angles is called **obtuse,** as ∠e.

An angle of two right angles is called a **straight** angle, for its two sides lie in the same straight line on opposite sides of the vertex. Thus ∠a and ∠e together form a straight angle.

The candidate should always bear in mind that a right angle measures 1600 mils, 90°, or 100 grads.

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A straight line cutting two other straight lines is called a **transversal.** Angles situated as ∠c and ∠f in Figure 3, or as ∠d and ∠e, are called **alternate interior angles.**

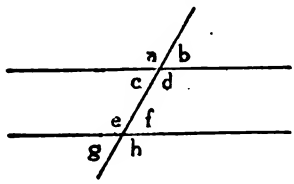

FIG. 3.

Parallel Lines.—Two lines are parallel if they lie in the same plane and do not meet however far they may be extended. Through any point can be drawn one parallel to a given line, but only one.

In Field Artillery the most useful of all the theorems concerning angles is the following:

When two parallel lines are cut by a transversal the alternate interior angles are equal.

Thus in Figure 3, ∠c = ∠f and ∠d = ∠e. We note that there are two sets of four equal angles:

∠s a, d, e, and h are equal, and ∠s b, c, f, and g are equal.

The converse of this theorem is also true; namely, if two lines are cut by a transversal and the alternate interior angles are equal, the lines are parallel.

The Angles of a Triangle.—We can apply the preceding theorem to prove the following:

The sum of the three angles of a triangle is equal to two right angles.

To prove this we first draw through one vertex a parallel to the opposite side, as BD in Figure 4.

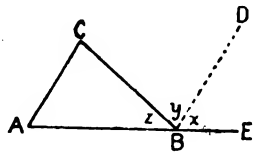

FIG. 4.

Since BC is a transversal cutting the parallel lines AC and BD, we know from the preceding theorem that ∠C = ∠y. Likewise considering the transversal AB, we see that ∠A = ∠x. So the sum of the three angles of the triangle is the sum of the ∠s x, y, and z.

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This sum is two right angles, for the three angles together form the straight angle ABE, and the theorem is proved.

The angle CBE is called an exterior angle of a triangle. In the above proof we have shown that **an exterior angle of a triangle is equal to the sum of the two opposite interior angles.**

If one of the angles of a triangle is a right angle, the sum of the other two must be a right angle, in order that the sum of the three shall be two right angles. Therefore,

The acute angles of a right triangle are complementary.

The following theorem can often be used as a check to avoid making gross errors.

If two sides of a triangle are unequal, the angles opposite them are unequal and the greater angle is opposite the greater side.

That is, in any triangle the greatest angle is opposite the longest side and the smallest angle opposite the shortest side. This is exem-

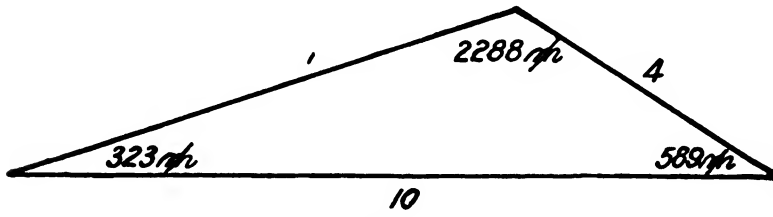

FIG. 5.

plified in Figure 5. It should be noted that the angles are NOT proportional to the sides; the exact relationship involves trigonometry.

A further property of triangles is that any side is less than the sum of the other two sides, and greater than their difference.

Isosceles Triangles.—A triangle is called **isosceles** if two of its sides are equal. **The angles opposite the equal sides are equal.**

If all the sides are equal, the triangle is called **equilateral.** In this case the three angles are equal.

Angles with Parallel or Perpendicular Sides.—The following theorems are important.

Two angles whose sides are respectively parallel are either equal or supplementary.

Thus in Figure 6 the sides of $\angle$ a and $\angle$ c are parallel. They are equal since each is equal to $\angle$ b. The sides of $\angle$ d and $\angle$ a are parallel; $\angle$d is the supplement of $\angle$c and is therefore the supplement of $\angle$a.

Two angles whose sides are mutually perpendicular are either equal or supplementary.

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Thus in Figure 7 the sides of ∠a and ∠c are perpendicular. Since ∠a and ∠b are the acute angles of a right triangle they are com-

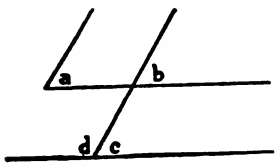

FIG. 6.

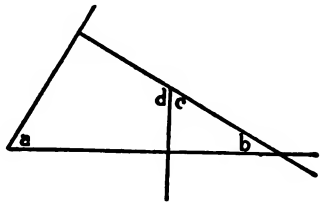

FIG. 7.

plementary. For the same reason ∠c and ∠b are complementary. Hence ∠a and ∠c, being complementary to the same angle, are equal. The ∠d, whose sides are perpendicular to those of ∠a, is the supplement of ∠a.

In applying these theorems it is usually possible to tell at a glance whether two angles under consideration are equal or supplementary.

The first of these theorems is extremely important. Very frequently, instead of measuring an angle directly, lines parallel to the sides of the angle are drawn through some convenient point, and the angle between them is measured.

Problems in Deflection

One of the first geometrical problems in gunnery is concerned with a quadrilateral, or four-sided figure. In Figure 8, G is the directing piece (usually the right gun of the battery), T is the target, A is the aiming point (some prominent object in the field of view), and B is the battery commander's station.

The angles ABT and AGT are always measured from A around to

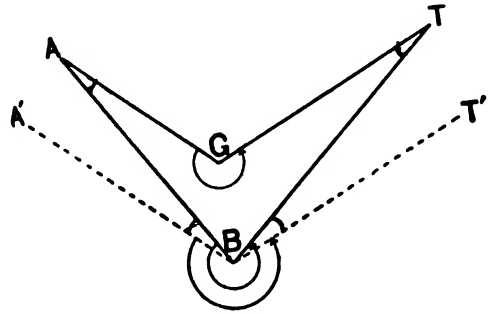

FIG. 8.

T in a **counter clockwise** direction; that is, in a direction contrary to the motion of the hands of the clock.

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Deflection of the Directing Piece.—The angle AGT is called the **deflection of the directing piece.** This angle must be found and set off so that when the sight is set on the aiming point the gun is laid on the target.

The angle ABT is measured at the B. C. station; the angles A and T are calculated (the method of finding them will be explained later); and from this data the deflection of the directing piece is found. The easiest method of finding this angle is by drawing lines through B parallel to AG and GT. Thus in the figure, angle ABA′ = angle A and angle TBT′ = angle T, whence angle A′BT′, which is equal to angle AGT, is found at once.

The geometry of the problem is quite easy. The student should become thoroughly familiar with it.

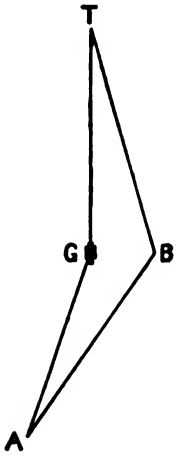

FIG. 9.

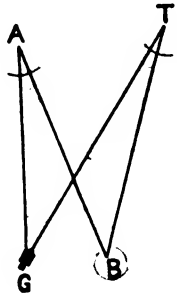

FIG. 10.

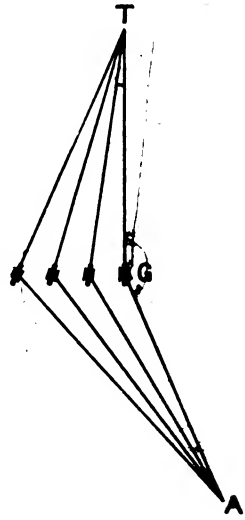

FIG. 11.

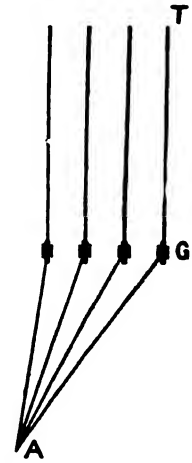

FIG. 12.

Exercises.—

Find the deflection of the directing piece in each of the following problems

1. Fig. 9, ABT = 4220 mils, A = 308 miis, T = 290 mils. Ans. 3622 mils.
2. Fig. 10, ABT = 5335 mils, A = 165 mils, T = 210 mils. Ans. 5290 mils.

Deflection of the Other Pieces

3. In Figure 11 find the deflections of the other pieces if angle AGT = 2890 mils, each angle at A is 5 mils, and each angle at T is 20 mils. Ans. 2865 mils, 2840 mils, 2815 mils.

4. Find the deflections of the other pieces in the preceding problem if the guns are laid parallel as in Figure 12. Ans. 2890 mils, 2885 mils, 2880 mils.

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The Pythagorean Theorem.—In a right triangle the square of the hypotenuse is equal to the sum of the squares of the two sides.

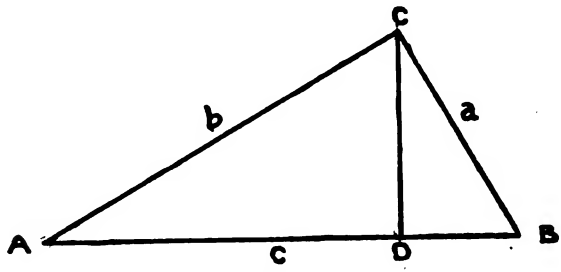

FIG. 13.

This important theorem can be proved by similar triangles. In Figure 13, CD is drawn perpendicular to the hypotenuse. The triangles ABC, ACD, and BCD are easily shown to have equal angles and therefore to be similar.

In ABC and ACD the sides c and b are corresponding, and b and AD are corresponding. $c/b = b/AD$, or $b^2 = c \times AD$. In ABC and BCD, the sides c and a are corresponding and a and DB are corresponding. Hence $c/a = a/DB$ or $a^2 = c \times DB$. Adding the two equations, we have:

$$a^2 + b^2 = c\,(AD + DB) = c^2.$$

Trigonometry

The Trigonometric Functions.—Trigonometry is the science of the exact measurement of the triangle. When certain of the sides and angles of a triangle are known, we are enabled to compute the remaining sides and angles. Instead of using the angles directly we employ certain **ratios** or **functions** connected with them.

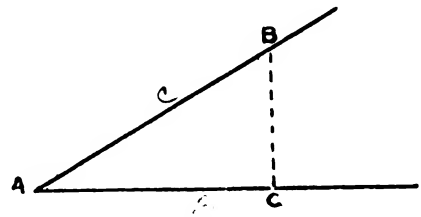

FIG. 14.

Let A (Figure 14) be an acute angle. From a point B on one side drop a perpendicular BC to the other side, thus forming a right

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triangle. Then the sine, cosine, tangent, and cotangent of the angle A are defined as follows:

$$\text{sine of } \angle A = \sin A = \frac{CB}{AB} = \frac{\text{opposite side}}{\text{hypotenuse}}$$

$$\text{cosine of } \angle A = \cos A = \frac{AC}{AB} = \frac{\text{adjacent side}}{\text{hypotenuse}}$$

$$\text{tangent of } \angle A = \tan A = \frac{CB}{AC} = \frac{\text{opposite side}}{\text{adjacent side}}$$

$$\text{cotangent of } \angle A = \cot A = \frac{AC}{CB} = \frac{\text{adjacent side}}{\text{opposite side}}$$

These ratios are called "trigonometric ratios" or "trigonometric functions."

It should be noted that these ratios depend merely upon the magnitude of the angle A and not upon the size of the triangle ABC. Thus if B had been taken ten times as far from A as in the figure, the sides of the triangle would all have been ten times as large, and the ratios would have been the same as before. For example, if AC = 4, CB = 3, AB = 5, we have sin A = 3/5, cos A = 4/5, tan A = 3/4, cot A = 4/3. If B is taken ten times as far from A, we have AC = 40, CB = 30, AB = 50; then sin A = 30/50 = 3/5; cos A = 40/50 = 4/5, etc.

If the angle A is given it is possible to determine the trigonometric functions graphically. The angle can be drawn by means of a protractor; a perpendicular is dropped from a point on one side to the opposite side; and the three sides of the triangle are measured. Their ratios are then computed.

Conversely, if one of the trigonometric functions is known the angle can be constructed. For example, if tan A = 2/3 we draw a right triangle whose legs are 2 units and 3 units in length. The angle opposite the leg of length 2 units is the angle A. We can now find the other functions. The hypotenuse is $\sqrt{13}$; hence, sin $A = \frac{2}{\sqrt{13}}$, cos $A = \frac{3}{\sqrt{13}}$, etc.

Solution of Right Triangles.—By means of the trigonometric functions we can find all the sides and angles of a right triangle, provided we know either two sides or one side and one acute angle. Some of the work can be done without the use of trigonometry. Thus if one acute angle is known we know that the other acute angle is its complement. Also if two sides are given the third can be

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found by using the equation $c^2 = a^2 + b^2$ (Figure 15). All other cases require the use of the trigonometric functions.

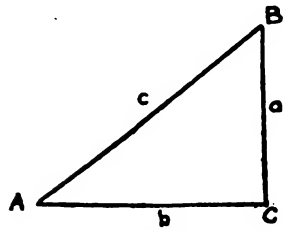

FIG. 15.

If an angle is to be found when two sides are known, write the function of the angle which is equal to the ratio of the two known sides, and from this the angle can be found. For example, if a = 6, b = 11, and we wish to find A, we have tan A = 6/11 = .5455, whence A = 509 mils. If b = 12, c = 25 we should use the cosine to find A, thus cos A = 12/25 = .4800, whence A = 1090 mils.

If a side is to be found when an angle and another side are known, write the function of the known angle which involves the known side and the side to be found. For example, if a = 16, A = 1220 mils and it is desired to find c, we have sin 1220 mils = 16/c. Since sin 1220 mils = .9312, we have c = 16/.9312 = 17.18. As a second example, if B = 36°, a = 109, and b is desired, we have tan 36° = b/109. We find tan 36° = .7265, whence b = 109 × .7265 = 79.19.

Trigonometric Functions of Obtuse Angles.—We have so far defined the trigonometric functions only for acute angles. For the solution of the general triangle it is often necessary to use the functions of obtuse angles. Dropping a perpendicular from a point B on one side (Figure 16) to the opposite side extended a right

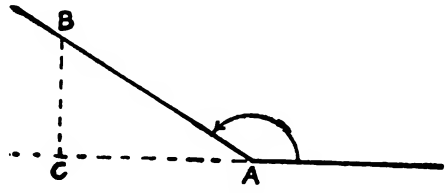

FIG. 16.

triangle is formed. The functions are defined as before with one difference: the line AC, which is measured in a direction opposite to that in which the side of the angle is drawn, is negative. Since

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AC appears in the ratios defining the cosine, tangent, and cotangent, we see that these functions are all negative for obtuse angles. The sine, however, remains positive.

If in Figure 16 AB = 5, CB = 3, and CA = 4 we have sin A = 3/5, cos A = − 4/5, tan A = −3/4, cot A = −4/3.

We note that the functions of the angle CAB, which is the supplement of A, are defined by the same ratios as are used for A except that CA is positive. From this we see that **the sine of an angle is equal to the sine of its supplement; the cosine, tangent, and cotangent of an angle are equal to the negative of the cosine, tangent, and cotangent respectively of its supplement.** These facts enable us to find the functions of obtuse angles from a table of functions of acute angles.

Solution of Oblique Triangles.—The triangle consists of six parts —three sides and three angles. If three of these parts, at least one of which is a side, are known, the remaining parts can be found. There are two general formulas which are sufficient to solve all cases. They are called the Law of Sines and the Law of Cosines.

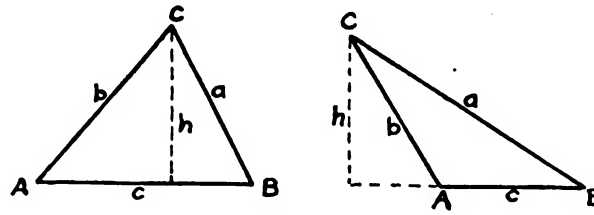

FIG. 17.

The Law of Sines.—In trigonometry it is customary to represent the angles of a triangle by the capital letters, A, B, C and the sides opposite these angles by the small letters a, b, c. Let h be the length of the perpendicular from C to the opposite side. Then, from either of the triangles in Figure 17 we see that

$$\sin A = \frac{h}{b}, \text{ or } h = b \sin A;$$

$$\sin B = \frac{h}{a}, \text{ or } h = a \sin B.$$

Whence

$$a \sin B = b \sin A, \text{ or } \frac{a}{b} = \frac{\sin A}{\sin B}$$

Stating this formula in words: **The ratio of any two sides of a triangle is equal to the ratio of the sines of the opposite angles.**

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The Law of Sines is sufficient to solve a triangle when a side and two angles are known, or when two sides and an angle opposite one of them are known.

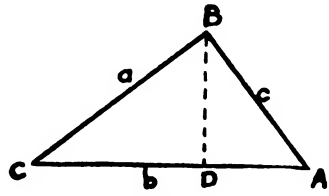

FIG. 18.

The Law of Cosines.—In Figure 18 let us express the side c in terms of a, b, and C. Drawing the altitude BD we note that,

$$c^2 = DA^2 + DB^2$$

Now $$\cos C = \frac{CD}{a} \text{ or } CD = a \cos C.$$

Whence $$DA = b - CD = b - a \cos C$$
$$DB^2 = a^2 - CD^2 = a^2 - a^2 (\cos C)^2$$

Therefore

$$c^2 = (b - a \cos C)^2 + a^2 - a^2 (\cos C)^2$$
$$= b^2 - 2ab \cos C + a^2 (\cos C)^2 + a^2 - a^2 (\cos C)^2;$$

or $$c^2 = a^2 + b^2 - 2ab \cos C.$$

Stating the formula in words: **The square of any side of a triangle is equal to the sum of the squares of the other two sides minus twice the product of these two sides multiplied by the cosine of their included angle.**

The Law of Cosines can be used to find the third side when two

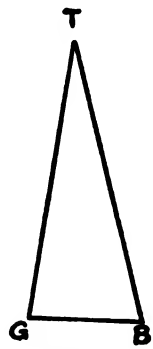

FIG. 19.

sides and their included angle are known. It can also be used to find any one of the angles when the three sides are known.

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Example.—The following example illustrates the use of the preceding formulas:

In order to find the range GT (see figure 19), a base line BG was measured and the angles B and G determined. If BG = 60 yds., G = 89° 43′, B = 87° 14′, find the range.

$$T = 180° - (89° 43' + 87° 14') = 3° 3'.$$

By the Law of Sines,

$$\frac{GT}{BG} = \frac{\sin B}{\sin T}, \text{ or } GT = BG \times \frac{\sin B}{\sin T}$$

From Trigonometric Tables we find

$$\sin 87° 14' = .9988, \qquad \sin 3° 3' = .0532$$

Hence

$$GT = \frac{60 \times 9988}{.0532} = 1126 \text{ yds.}$$

Components.—The flight of a projectile is affected by the wind. A rear wind increases the range and a head wind decreases the range, but neither affects the deflection. A cross wind affects the deflection but does not affect the range. The range table gives data for calculating these effects.

In practice the wind seldom blows exactly in the direction of fire or directly across it. Usually therefore the wind affects both range and deflection. In order to find its effect it is necessary to replace the wind by **two** winds which together have the same effect, one in the direction of fire (a rear or head wind), and the other perpendicular to the direction of fire (a cross wind). These two winds are called the **components** of the given wind in the two directions.

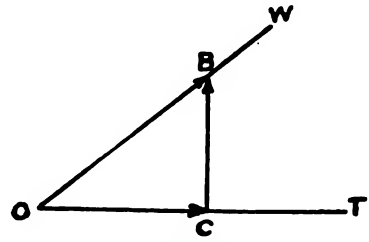

FIG. 20.

In Figure 20 let OT be drawn in the direction of fire and OW in the direction the wind is blowing. Choose any convenient unit to represent the unit velocity (1 mi. per hr., if the velocity of the wind is expressed in miles per hour). With this unit lay off OB to represent the wind's velocity, and drop the perpendicular BC to OT. Then OC is the range component of the wind and CB is the deflection component. The velocities can then be measured directly: or, by trigonometry, OC = OB cos O, CB = OB sin O. For ex-

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ample if the wind is blowing 11 mi. per hr., and its direction makes an angle of 420 mils with the direction of fire we have:

Range component of wind = 11 cos 420 mils = 11 × .9162 = 10.1 mi. per hr.

Deflection component of wind = 11 sin 420 mils = 11 × .4008 = 4.4 mi. per hr.

It must be borne in mind that OW is drawn in the direction the wind is blowing, not in the direction from which it comes.

The use of components is not confined to wind velocities alone. Any velocity can be resolved into components along two directions. For example if a troop of cavalry is approaching along a line making a certain angle with the line joining the troop to the battery and traveling at a given speed, we can find by taking components, the rate at which the range of the troop is decreasing and the rate at which the deflection is changing.

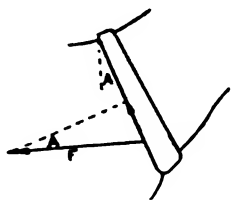

FIG. 21.

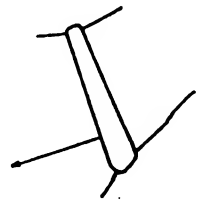

FIG. 22.

Forces are also commonly resolved into components. For example, consider the position of the trace in draft. The shoulder of the animal is inclined to the vertical at an angle A (Figure 21). If the trace is horizontal there is a component of the force on the trace which acts tangent to the shoulder and which tends to push the collar upward. If F is the magnitude of the force, the magnitude of this component is F sin A. Thus if A = 300 mils, then sin A = .2903, and the component is .2903 F., or 29 per cent. of the pulling force. In artillery harness this is remedied by holding the trace down by means of the cincha so that the force is approximately perpendicular to the collar, as in Figure 22.

Approximate Methods

By the use of trigonometry the data necessary for laying the guns can be accurately determined. But where the battery must begin firing directly after going into position there is usually not time either to get accurate measurements from which to deduce the

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firing data or to make the calculations by means of trigonometric processes. Where time permits accurate work is highly desirable, but where it does not, as usually occurs in open warfare, accuracy must be sacrificed to speed. The methods treated in this section are in common use and should therefore be thoroughly understood by the student.

Approximate Length of Arc.—If r is the radius of a circle we have:

$$\text{Circumference} = 2 \text{ pi } r = 6.2832 \text{ r.}$$

The arc which subtends an angle of 1 mil at the center is 1/6400 of this:

$$\frac{6.3282 \text{ r}}{6400} = .000982 \text{ r} = \frac{1}{1000} \text{ r, about.}$$

That is, the arc which subtends an angle of 1 mil at the center is approximately 1/1000 of the radius.

To find accurately the angle subtended by 1/1000 of the radius we have:

$$\frac{001 \text{ r}}{6.2832 \text{ r}} \times 6400 \text{ mils} = 1.019 \text{ mils.}$$

From the preceding we can state the following rule: **The arc which subtends a given angle at the center of a circle is approximately equal to the number of mils in the angle multiplied by 1/1000 of the radius.**

Conversely, **the angle (in mils) at the center subtended by a given arc is approximately equal to the length of the arc divided by 1/1000 of the radius.**

We see from the preceding numbers that the application of either of these rules will give an error of about 2 per cent. If the angle is given the arc found will be 2 per cent. too great; if the arc is given the angle found will be 2 per cent. too small. These errors would have been avoided if the mil had been defined as 1/6283.2 of the complete circle instead of 1/6400 of it, but this kind of division would be very awkward. Furthermore a 2 per cent. error is unimportant in view of the fact that the rapid determination of ranges may give errors much in excess of 2 per cent.

Chords, Tangents, etc., of Small Angles.—At the top of Figure 23 is an angle of 100 mils. At the bottom of the figure is shown the arc considerably enlarged. We observe that there is but slight difference between the lengths of the arc AB, the chord AB, the tangent AC, and the line AE, drawn from A perpendicular to the

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opposite side. In fact the length of any line, such as AD, drawn from A to the opposite side and which is very nearly perpendicular

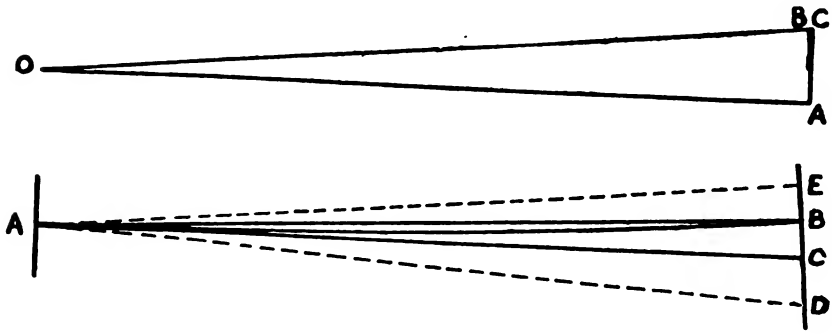

FIG. 23.

to one side of the angle does not differ greatly from the length of the arc.

As a consequence of the preceding observations we have the following rule, which is of great use in field artillery.

The angle (in mils) subtended at a point by a distant line is approximately equal to the length of the line divided by 1/1000 of its distance provided the line is short in comparison with its distance and is approximately perpendicular to a line joining it to the given point.

It is apparent that this rule will not give very accurate results for large angles. But when the angle at the point does not exceed 200 mils and when the line does not incline more than 200 mils from the perpendicular the error will in the most unfavorable case be less than 2½ per cent.

Trigonometric Functions of Small Angles.—In Figure 23 OA and OC are very nearly equal in length and AC is approximately 1/1000 of OA multiplied by the number of mils in the angle. From this we find:

$$\sin O = \frac{AC}{OC} = \frac{1}{1000} \times \text{number of mils in the angle (approximately).}$$

$$\tan O = \frac{AC}{OA} = \frac{1}{1000} \times \text{number of units in the angle (approximately).}$$

$$\cos O = \frac{OA}{OC} = 1 \text{ (approximately).}$$

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We see from Trigonometric Table of angles in mils that these approximate definitions are in error less than 2 per cent. (a) for the sine if the angle is less than 120 mils, (b) for the cosine if the angle is less than 200 mils, and (c) for the tangent if the angle is less than 340 mils.

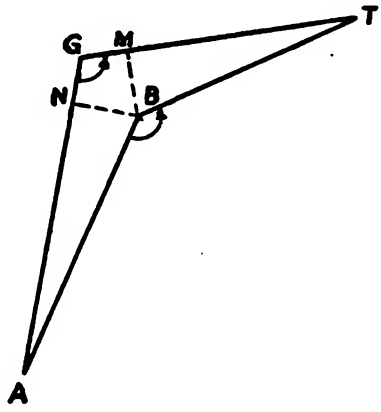

FIG. 24.

Determination of Firing Data.—In the discussion of deflection in geometry we showed how to find the deflection of the directing piece (angle AGT) when the angle ABT and the angles A and T are known (see Figure 24). The angle ABT is measured directly by the battery commander at B. We shall now show how the angles A and T are determined. By means of a range finder, or otherwise, the battery commander determines the ranges BT and BA. He then estimates the distances BM and BN from his station to the lines joining the battery to the target and the aiming point. He has then:

$$\angle T = BM \div \frac{1}{1000} \text{ of } BT.$$

$$\angle A = BN \div \frac{1}{1000} \text{ of } BA.$$

There is, of course, a chance of considerable error in estimating the distance to an imaginary line. However the points A, G, T are generally all visible and he can tell roughly where the lines joining them will pass.

Parallax.—The parallax of a point with respect to a line is the angle subtended at the point by the line. Thus in Figure 25 the parallax of P with respect to the line AB is the angle APB, the paral-

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lax of K is the angle AKB, and so on. Looked at in another way the parallax of P is the amount by which the lines AP and BP differ in direction. Every object has a parallax with respect to the line joining one's two eyes, which is easily noticeable if first one eye then the other is closed. In Field Artillery the term "parallax" is frequently restricted to the parallax with respect to a platoon front of twenty yards, which is also the distance between successive guns of a battery. As a consequence parallax is of importance in the computation of firing data, and of deflection differences in particular.

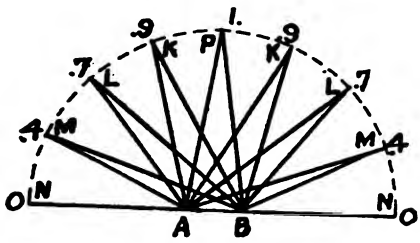

FIG. 25.

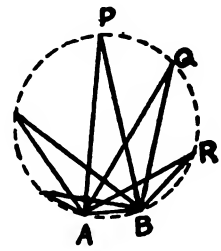

FIG. 26.

From the geometric theorem that inscribed angles that intercept the same arc are equal, it follows that **all points lying on a circle through the ends of a line, and lying on the same side of a line have the same parallax with respect to the line.** Thus in Figure 26, the points P, Q, and R have the same parallax with respect to AB. Points outside this circle have a smaller parallax, and those inside have a larger parallax

If the length of AB is small in comparison with the range of P and if P lies on or near the perpendicular bisector of AB, as in Figure 25, then the parallax in mils of P with respect to AB may be obtained by dividing AB by 1/1000 of the range.

Obliquity.—If a point whose parallax is to be determined lies at a considerable distance from the perpendicular bisector of the line, then the rule for finding the parallax given in the preceding paragraph no longer applies. For, from Figure 25, it is obvious that while P, K, L, M, N have the same ranges, their parallaxes differ. The parallax has its largest value at P, while it decreases to zero at N.

From Figure 27 it is clear that the parallax of P with respect to AB is the same as its parallax with respect to BC, the perpendicular from B to AP. Now from Trigonometry it follows that:

$$BC = AB \cos x.$$

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We get the angle at P by dividing BC by 1/1000 of the range, and so we obtain the rule that the parallax of P with respect to AB,

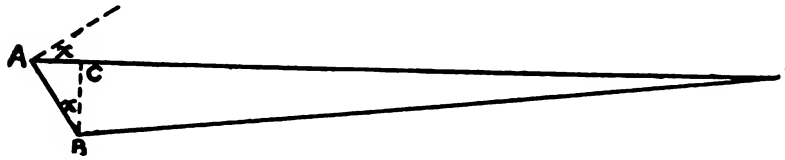

FIG. 27.

when AB is small in comparison with the range to P, is found by dividing AB by 1/1000 of the range and multiplying the result by the cosine of x. The angle x is called the **obliquity,** and cos x is called the **obliquity factor.**

The common method of finding the obliquity is to find the angle between a perpendicular to AB and a line to the point P. Thus the angle marked x at A in Figure 27 is equal to the angle ABC, the sides of the angles being mutually perpendicular.

For rapid work in the field the value of x is roughly estimated and the obliquity factor is approximated. On account of the ease with which the submultiples of a right angle are estimated, only the cosines of 0 mils, 400 mils, 800 mils, 1200 mils, and 1600 mils, are used, and these correct to only one decimal place. The following table shows the cosines to four places, and the obliquity factors used:

x = 0 mils,	400 mils,	800 mils,	1200 mils,	1600 mils.
Cos x = 1.0000,	.9239,	.7071,	.3827,	.0000.
Obliquity factor used = 1,	.9,	.7,	.4,	.0.

It is customary to use the same obliquity for angles within 200 mils of each of these angles; that is the factor 1 is used for angles from 0 mils to 200 mils, the factor .9 is used for angles from 200 mils to 600 mils, and so on. More accurate values would be obtained by interpolating for intermediate angles; and, since the labor of interpolating between one figure numbers is negligible, interpolation would appear to be preferable to the method just described.

The use of these simple factors renders the work easy; but errors much in excess of the 2% or 3% errors of the approximate methods previously discussed are introduced. However, the parallaxes found in practice are very small angles, and considerable percentage errors do not materially affect the accuracy of the work.

Firing Data.—In Figure 24 the problem of finding the angles A and T presents itself. These angles are the parallaxes of the

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points A and T with respect to the line BG. By measuring or estimating the length of this line and determining the obliquities of A and T with respect to it, the parallaxes can be found by the methods just described.

There are three systems of units used in measuring angles in Field Artillery:

The Degree and its Subdivisions.—A degree is 1/360 of a complete rotation. Hence if the circumference of a circle be divided into 360 equal parts an angle whose vertex is at the center is measured in degrees by the number of these parts lying between the sides. The degree is subdivided as follows:

1 degree (1°) = 60 minutes (60′)
1 minute = 60 seconds (60″)

These units are used on most heavy guns and on engineering instruments.

The Grad.—A grad is 1/400 of a complete rotation. If the circumference be divided into 400 equal parts an angle at the center

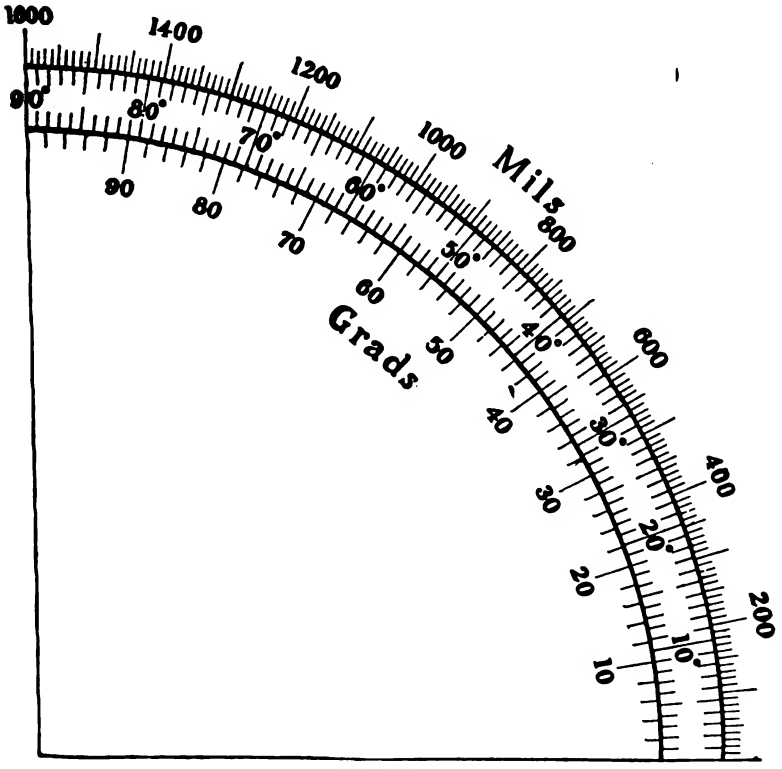

FIG. 28.

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is measured in grads by the number of these parts lying between the sides. The prefixes of the Metric System are used with the grad. Thus, 1 grad = 10 decigrads, etc.

The grad is used by the French in wind bulletins.

The Mil.—A mil is 1/6400 of a complete rotation. If the circumference be divided into 6400 equal parts an angle at the center is measured in mils by the number of these parts lying between the sides. The mil is used more than any other unit in Field Artillery.

It will be shown later that a yard stick held perpendicular to the line of sight at a distance of 1000 yds. subtends at the eye an angle of about 1 mil, and this fact will prove very useful later. However, this is NOT the definition of a mil, although it is sometimes given as such; a mil so defined would be almost 2% too great.

Conversion of Units.—The following relation should be borne in mind, as it furnishes all the information necessary to convert from one system of units to another:

1 complete rotation = 360° = 400 grads = 6400 mils.

A quarter of a complete rotation is called a **right angle.** The sides of a right angle are said to be **perpendicular.**

1 right angle = 90° = 100 grads = 1600 mils.

We find at once the following:

1° = 10/9 grads = 160/9 mils.
1 grad = 9/10° = 16 mils.
1 mil = 9/160° = 1/16 grads.

The Use of Tables

Much of the information that the Field Artillery officer requires is to be found in tables. The angle at which the gun must be elevated to reach a given target, and the effects of wind, of the rotation, of the shell, of variation in the weight of the projectile, and of the condition of the powder—to mention only a few items—are got from tables. It is clear, therefore, that he should be able to use a table rapidly and accurately.

All tables are much alike. Two quantities depend upon one another in such a way that when one is known the other can be found. In forming a table, several values of one of the quantities are written down, and the corresponding values of the other are calculated and entered. The following data from the range table of the 3-inch gun are an example.

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R	T	V
2000	4.75	1039.0
2100	5.05	1021.7
2200	5.35	1005.3
2300	5.65	989.8
2400	5.95	975.2
2500	6.26	961.5
2600	6.57	948.7
2700	6.88	936.7
2800	7.19	925.5
2900	7.51	915.1
3000	7.83	905.5

In this table R represents the distance to the target (the range), in yards; T is the time the projectile is in the air (time of flight) in seconds; and V is the velocity with which it strikes the ground (terminal velocity), in feet per second.

Interpolation.—The table does not give all the values of the quantities, but only values at intervals. Thus R is given at intervals of 100 yards, and the corresponding values of T and V entered. The intermediate values are not given, and the process of finding them is called **interpolation.**

To illustrate the method, we shall find T when R is 2420. R lies between 2400 and 2500, hence T lies between 5.95 and 6.26. Now 2420 is .2 of the way from 2400 to 2500; then T will be .2 of the way from 5.95 to 6.26. The interval from 5.95 to 6.26 is 31, and $.2 \times .31 = .06$ (to two places). Therefore

$$T = 5.95 + .06 = 6.01.$$

To find V when R = 2420 we note that the interval between 975.2 and 961.5 is 13.7 and .2 of this interval is 2.7 (to one decimal place). Therefore

$$V = 975.2 - 2.7 = 972.5,$$

the quantity being subtracted because V is decreasing as R increases.

In this table T is correct to two decimal places, and V is correct to one decimal place. The quantities added or subtracted in making the interpolation **should not be carried to a greater number of places.**

The rule governing interpolation is the same for all tables: The given value lies between two consecutive entries in one column, dividing the interval between them in a certain ratio; the value to be found lies between the corresponding entries in another column and divides the interval between them in the same ratio.

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As an additional example we shall find V when T = 6.40. The work is as follows:

6.57	6.40	961.5	14
6.26	6.26	948.7	$\frac{}{31} \times 12.8 = 5.8$
.31	.14	12.8	

$$V = 961.5 - 5.8 = 955.7.$$

The Trajectory

1. **Definitions:**

Angle of departure: The angle between the plane of site and the line of departure.

Angle of fall: The angle between the plane of site and the tangent to the trajectory at the point of fall.

Angle of incidence: The angle between the plane of the surface struck and the tangent to the trajectory at the point of impact.

Burst center, center of burst, or **mean point of burst:** The point about which the points of burst of several projectiles are evenly distributed.

Burst interval: The distance in the plane of site from the point of burst to the target.

Burst range: The distance in the plane of site from the muzzle of the gun to the point of burst.

Counter slope: A slope which descends toward the enemy and is wholly or partially hidden from him by the covering crest of the reverse slope.

Crest: The summit of a ridge.

Curved fire: Fire with low muzzle velocity, the elevation not exceeding 540 mils.

Danger space: The distance, in the plane of the slope considered, over which an object of a given height would be struck.

Deflection: The angle between two vertical planes containing, one the line of sight, and the other the axis of the bore.

Deflection center: The point about which bursts in air or on impact are evenly distributed in direction.

Direct fire: Fire with high muzzle velocity, the elevation not exceeding 360 mils.

Direct laying: Pointing the gun for direction and elevation by directing the line of sight upon the target.

Drift: The departure of the projectile from the plane of fire due to its rotation and to the resistance of the air.

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Elevation: The angle between the plane of site and the axis of the bore when the gun is laid.

Height of burst: (1) The vertical angle between the plane of site and a right line joining the muzzle of the gun and the point of burst. (2) The ordinate of a point of burst.

Height-of-burst center: The point about which bursts in air are evenly distributed in height.

High angle fire: Fire with elevation exceeding 540 mils.

Indirect laying: Pointing the gun for direction by directing the line of sight upon an objective other than the target, and for elevation by the use of a quadrant or elevation level.

Jump: The angle between the line of departure and the axis of the bore before firing; hence, the difference between the elevation and the angle of departure.

Line of departure: The prolongation of the axis of the bore at the instant the projectile leaves the gun.

Line of sight: The right line passing through the sights and the target or the aiming point.

Mean height of burst: (1) The height of the burst centers. (2) The average of several heights of bursts.

Mil: The unit of angular measure, one sixty-four-hundredth of a circle. The arc which subtends a mil at the center of a circle is, for practical purposes, equal to one one-thousandth of the radius. The arc and its tangent are nearly equal for angles not greater than 330 mils. The symbol for mils is *m*.

Military crest: The line nearest a crest from which all the ground toward the enemy may be seen and reached by fire.

Muzzle velocity: The velocity of the projectile at the instant it leaves the bore. Velocities are measured along the tangent to the trajectory at the point considered and are expressed in feet per second.

Normal corrector: The corrector setting which gives a normal height.

Normal height: The height of burst giving the maximum effect from a projectile.

Ordinate: The distance of a point of the trajectory from the plane of site. The **maximum ordinate** is the ordinate of the highest point of the trajectory.

Parallax: The angle at any point subtended by any given line.

Plane of fire: The vertical plane through the line of departure; also called **plane of departure.**

Plane of site: A plane containing the right line from the muzzle of the gun to the target, and a horizontal line perpendicular to the axis of the bore at the muzzle.

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Point of burst: The point at which a projectile bursts in the air or at which it would have burst in the air had it not struck the ground.

Point of fall, of impact or **of graze:** The point where the projectile strikes.

Probable error: The amount of error that, in a large number of occurrences, will be as often exceeded as not.

Quadrant angle of departure: The angle between a horizontal plane and the line of departure.

Quadrant elevation: The angle between a horizontal plane and the axis of the bore when the gun is laid.

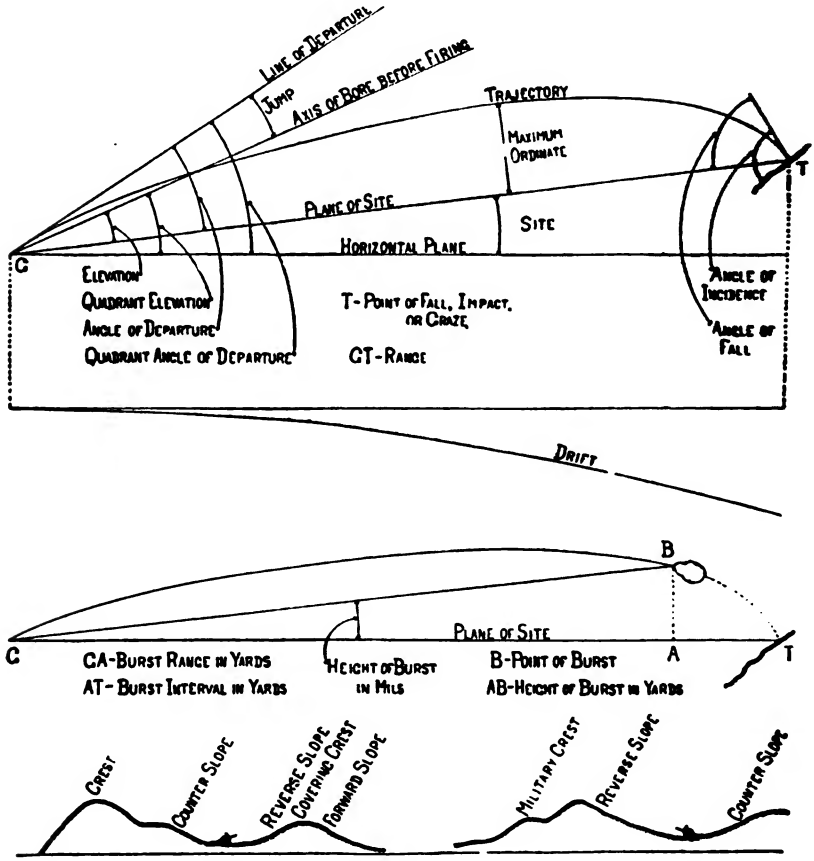

FIG. 29.

Range: The distance from the muzzle of the gun to the target.

Range center, center of impact, or **mean point of fall:** The point about which the points of fall, reduced to the plane of site, are evenly distributed.

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Range-of-burst center: The point about which bursts in air are evenly distributed in range.

Site: The angle between a horizontal plane and a right line joining the muzzle of the gun and the target; also called the **angle of position.** The origin of site scales is taken at 300.

Trajectory: The path described by the projectile in its flight.

Remaining velocity: The velocity of the projectile at any point of the trajectory.

Reverse slope: The slope which, from the direction of the enemy, is hidden by a ridge of which the slope is a part.

Terminal or **striking velocity:** The remaining velocity at the point of burst or point of fall.

Time of flight: The time in seconds required for the projectile to travel from the muzzle of the gun to any point of the trajectory—usually to the point of fall or of burst. (Par. 1044, Drill and Service Regulations for Field Artillery, 1916.)

1. With reference to the burst interval, it should be noticed that this interval is measured to the target from the projection in the plane of site of the point of burst, and that the target is not necessarily at the point where the trajectory, produced if necessary, passes through the plane of site, as it is in the above figure. With reference to the range, it will be noticed that while the range from the guns to the target may not vary, the elevation of the guns may be changed and the distance covered along the plane of site, or gun range, varies.

2. On field pieces of the United States service, the range scales are graduated in yards, the least reading being 50 yards.

The corrector scales are graduated in points.

The angle of site scales and the deflection scales on all instruments are graduated in mils.

3. **The mil.** If a circumference be divided into 6400 parts, the angle at the center which is subtended by each one of these small divisions of the circumference is called a mil. If the radii which bound an angle of one mil be prolonged 1000 yards, the distance between the ends of the radii measured on the arc will be very nearly one yard. To understand this, it is necessary to remember that the circumference of the circle $2 = \times 3.1416 \times$ radius $= 6.283 \times$ radius $= 6283 \times$ radius/1000. This last expression means that if the circle be divided into 6283 equal angles and the radii which bound one of these angles be prolonged 1000 yards, the distance between the ends of the radii measured on the arc will be one yard. The number 6283 is inconvenient to use as it cannot be divided readily into equal parts; therefore, the circle is divided into 6400 parts.

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Practically, the error made by dividing the circle into 6400 instead of 6283 parts is negligible.

In this connection, instead of using the arc as the measure of the angle it is often convenient to use the sine or the tangent of the angle. In any right-angled triangle, the sine of either of the acute angles is equal to the ratio of the side opposite the angle to the hypotenuse; and the tangent is equal to the ratio of the side opposite the angle to the side adjacent. From a simple figure, it can be seen that for small angles, the value of an angle is practically the same whether measured by the arc, by the sine, or by the tangent.

4. Trajectory in vacuo. Trajectory in air. As ordinarily understood by practical artillerymen, the path followed by the projectile in its flight from the muzzle of the piece to the target is known as the trajectory of the projectile.

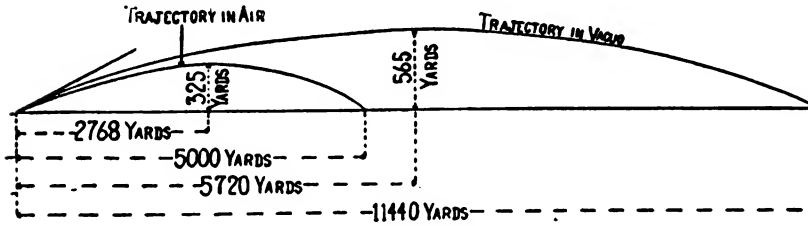

FIG. 30.

The relation between the elements of the trajectory is influenced by the angle of departure, by the muzzle velocity of the projectile, by the force of gravity, the resistance of the air, the rotation of the projectile around its axis, and other minor factors.

If the force of gravity, the resistance of the air, and the rotation of the projectile around its axis could be eliminated, the projectile would describe a straight line determined by the line of departure, and its velocity would remain constant.

The force of gravity causes the projectile to drop away from the line of departure, however, and, if the projectile were influenced only by the angle of departure, the muzzle velocity and the force of gravity, the trajectory would be a curve, the highest point of which would be the center of the trajectory, and both halves would be identical in shape. Such a trajectory is known as the **trajectory in vacuo.**

The resistance of the air, however, acts to retard the projectile, and from the instant the projectile leaves the muzzle tends continuously to reduce the velocity, so that the highest point of the **trajectory in air** is nearer to the far end of the trajectory and the

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two parts of the trajectory are unequal and unsymmetrical. (Par. 1045, D. and S. R.)

In Figure 30 are represented for purposes of comparison, the trajectory in air of a projectile fired from a 3-inch field gun at range 5000 yards and the trajectory in vacuo for the same angle of departure. In this figure the vertical scale has been doubled.

5. Drift. The rotation imparted to the projectile by the rifling of the piece, together with the resistance of the air, causes the projectile to deviate from the plane of fire.

The rifling of all field pieces in the United States service is constructed with a right-hand twist, and the resulting deviation of the projectile from the plane of fire is always to the right. This deviation is called **drift.** In the following remarks on the theoretical trajectory the drift is neglected, and the trajectory is considered to have been projected on the plane of fire.

6. Varieties of trajectories. The general form of trajectories depends on the nature (weight, shape, etc.), of the projectile, on its muzzle velocity, on the direction and velocity of its rotation, and on atmospheric conditions.

Supposing these elements to be constant, the form of the trajectory varies with the angle of departure. Assuming the plane of site to be horizontal, let the angle of departure be increased from 0° to 90°. As the angle of departure is increased, the angle of fall also increases, and the summit of the trajectory rises. When the angle of departure is about 45° the range is a maximum, after which the range decreases until practically zero when the angle of departure is 90°. A point short of the maximum range can then be reached by fire with two angles of departure, one less than, and the other greater than, the angle giving the maximum range. With guns and howitzers, only the smaller of these angles of departure is used for firing at any particular range. With trench and other types of mortars the larger angle is used.

Generally speaking, direct fire is delivered by guns, curved fire by howitzers, and high angle fire by mortars. Except in the case of fire on aerial targets for which special material is constructed, fire is rarely delivered with a quadrant angle of departure greater than 540 m. from guns, and greater than 720 m. from howitzers. The angle of departure for the 3-inch gun for the extreme range table range of 8500 yards is about 500 m.; that of the 6-inch howitzer for the maximum range in each of the three zones is about 700 m.

Figure 31 gives a general idea of the various trajectories of field pieces now in the United States service.

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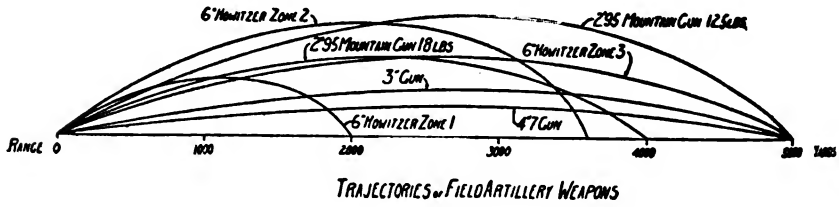
7. Rigidity of the trajectory. The range tables, which will be taken up later, are computed, strictly speaking, for horizontal planes of site. This is obviously rarely the case in field artillery firing. In order to simplify the mechanisms and methods of field



Trajectories of Field Artillery Weapons

Fig. 31.

artillery firing, use is made of what is known as the principle of the **rigidity of the trajectory.** So extensively is this principle applied that it may be said to underlie the whole theory of field artillery firing.

The principle of the rigidity of the trajectory is the assumption that the relations existing between the elements of the trajectory and the chord representing the range are the same whether the chord be horizontal or inclined. In other words, a trajectory remains rigid as to form and extent while it and its chord are revolved in a vertical plane about the origin (the muzzle) as a center through the relatively small angles required in field artillery firing.

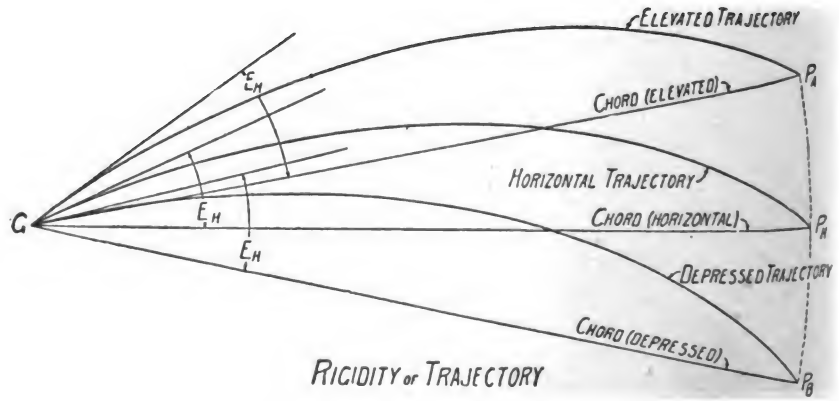


Fig. 32.

In Figure 32, three planes of site are shown, GPA, GPH, and GPB. G is the firing point. GPH is horizontal. PA, PH, and PB are all at the same distance from G. PH will be reached by a trajectory

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whose elevation above GPH, is EH, which value may be obtained from the range table. By the principle of the rigidity of the trajectory, if the gun be elevated above GPA by the same amount, EH, the trajectory will reach PA; and if the gun be elevated by EH above GPB, the trajectory will reach PB.

The principle is applied in both direct and indirect laying. The chord of the trajectory is directed at PA, PH, or PB, as the case may be, by the horizontal cross-hair in direct laying and by the site scale of the range quadrant in indirect laying. The piece is elevated above the chord by the range scale of the sight or quadrant. This elevation is obviously the same regardless of the position of the chord.

The inclination of the chord to the horizontal determines the angle of site.

The determination of the range of the horizontal trajectory which would pass through an elevated or depressed target would be impracticable in service, so that the application of the principle simplifies the practical laying of field pieces. The difference between the horizontal and inclined ranges is considerable only when the range is great and the site is what may be considered as extreme for field artillery firing; nevertheless, correction is sometimes made for this difference.

8. It follows that the quadrant angle of departure in any case is equal to the algebraic sum of the angle of the target and the angle of departure corresponding to the range of the target.

For indirect laying with the 3-inch gun, both the angle of site and the range are set off on the quadrant and the gun and cradle are then given the proper elevation. For a horizontal plane of site, the site scale is set at 300. The least reading of the site scale is one mil. Values of the angle of site greater than 300 correspond to targets situated above the level of the gun and vice versa.

In the case of the French 75-mm. gun, the angle of site is set off on the site scale and the rocker (berceau) is given the elevation corresponding to this angle; the range is set off on the range drum, which motion at once gives the gun an inclination to the rocker corresponding to the elevation for the range considered. The gun is thus laid with the quadrant elevation. For a horizontal plane of site, the site scale is set at zero. The least reading of the site scale is five mils. Plus values of the angle of site are used for targets above the level of the gun; minus values for those below that level. The range scale is graduated in meters, the least reading being 25 meters.

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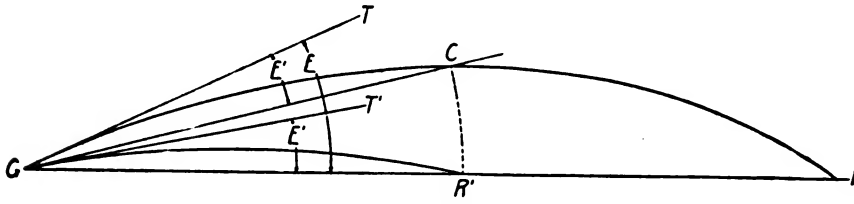
9. Construction of the trajectory. The principle of the rigidity of the trajectory affords a convenient means of constructing any trajectory simply from the range table and without calculation.



CONSTRUCTION OF TRAJECTORY

FIG. 33.

In Figure 33 let GCR be the trajectory of range GR, which it is desired to construct. Let GR′ be any intermediate range with its horizontal trajectory. GT and GT′ are the initial lines of departure for the two ranges GR and GR′ respectively. They make angles with the horizontal, E and E′ respectively which are the tabular values of the angle of departure for the two ranges.

Now if the trajectory GR′ and its initial tangent GT′ be rotated upward about G as a center until GT′ coincides with GT, the trajectory GR′ will, as far as it goes, coincide with the trajectory GCR, by the principle of the rigidity of the trajectory. The horizontal chord GR′, in its rotated position, will be GC, and the angle TGC will be equal to E′. GC will intersect the trajectory GCR in C, and GC will be equal in length to GR.

On this basis, the trajectory GCR may be constructed as follows:

Draw the horizontal line GR equal to the range of the trajectory it is desired to construct. Lay off the tangent GT making with GR the angle E equal to the tabular angle of departure for the range GR. Lay off the line GC making with GT an angle equal to the tabular angle of departure for any convenient intermediate range R′. Lay off on GC the distance GC equal to the range R′ C is then a point on the desired trajectory GCR. Similarly any desired number of points on the trajectory may be constructed by assuming different values for the intermediate range R′.

From this discussion it will be seen that, under the principle of the rigidity of the trajectory, for similar projectiles and charges, a particular weapon may be considered as having but one trajectory, the trajectories for long ranges being merely extensions of those for intermediate shorter ranges. Or, the trajectory for a range R is merely the part cut from the trajectory for the weapon by an arc of radius R with the origin as a center.

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The trajectory drawn as described above is not as accurate as when points of the curve are located by computation using the proper ballistic formulas.

10. Jump. The angle of departure differs from the elevation at which the piece is laid, by such derangement of the laying as takes place while the projectile is moving through the bore. This angular difference is called the **jump.**

The jump is upward, or positive, when the angle of departure is greater than the elevation. This is usually the case when the tube is mounted above the recoil-checking mechanism, as with the 3-inch and 75-mm. guns.

The jump is downward, or negative, when the angle of departure is less than the elevation. This is usually the case when the piece is mounted below the recoil-checking mechanism, as with the 6-inch howitzer.

For a given gun and carriage, the value of the jump varies with the elevation, the weight of the projectile, and with the charge. The average value in the case of the 3-inch gun is about 2 mils; for the 6-inch howitzer, from about 12 to 15 mils considering all zones; for the 75-mm. gun about 7 minutes for shrapnel, muzzle velocity 535 meters per second, and 1 minute for the lighter high explosive shell, muzzle velocity 550 m. s.

11. Manipulation of the trajectory. The location of the trajectory in the vertical plane depends upon the site and the elevation. It may be changed by changing one or the other of these elements, or the same location may be retained by making the proper change of both in opposite senses.

A variation of the site setting affects the range the same as an equal variation of the elevation.

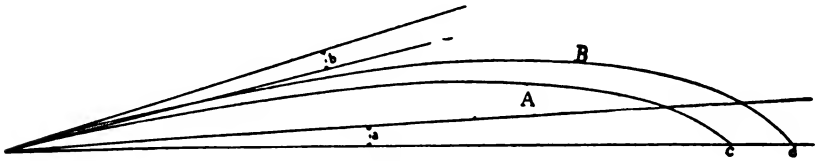

FIG. 34.

Given a certain trajectory A, a trajectory B with a greater range can be obtained either by increasing the elevation by the angle b, or by increasing the site by the angle a. If the angle a is equal to the angle b the resulting trajectories will coincide, since either change will produce a change in range equal to cd.

A change of range, the site and corrector remaining the same, changes the burst range but not the apparent height of burst.

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The apparent height of the shrapnel burst under normal conditions depends only on the site and the corrector.

FIG. 35.

If the site only is varied, the point of burst is displayed in height, but not in range; if the corrector only is varied the point of burst is displayed at the same time in both height and range. Simultaneous and corresponding but opposite changes of site and corrector cause practically no change in height of burst, but the burst range changes.

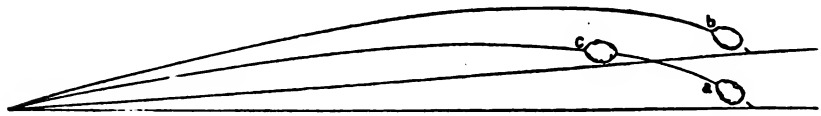

FIG. 36.

An increase in site only, changes the position of the burst from a to b, changing the height or burst but not the burst range.

An increase in corrector only, changes the position of the burst from a to c changing the apparent height of burst and also the burst range.

The burst range depends only on the fuse setter range and the corrector setting. It is increased or diminished by increasing or diminishing the fuse setter range or by lowering or raising the corrector.

The points of burst of two or more rounds are not coincident unless these three elements, the site, the corrector, and the range, remain constant, or unless all three change at the same time by suitable amounts and in the proper relation.

The distance in the plane of site from the point of burst to the point of impact can be obtained by multiplying the height of burst in mils by the range change caused by a change of one mil in elevation.

The differences in range shown in the range tables as corresponding to given variations of elevation are measured in the plane of site. On ground sloping up from the plane of site, as on a counter slope, the difference in distances to points of fall will be less than the difference in corresponding ranges given in the tables. On ground inclined in the opposite sense, as on a reverse slope, the

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difference in distances to points of fall will be greater than the difference in ranges in the tables. (Par. 1054, D. and S. R.)

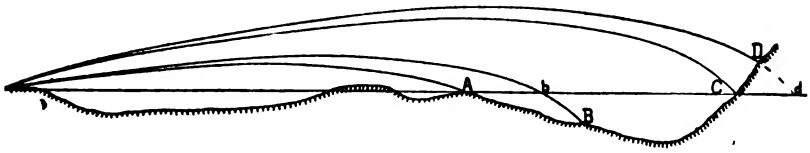

FIG. 37.

Counter slope: Distance CD is less than distance Cd.

Reverse slope: Distance AB is greater than distance Ab.

The above figures are not drawn to scale; the variations shown are diagrammatic and not exact.

The swinging of the trajectory to the right or left is effected by changing the deflection. By increasing the deflection by the amount of drift for any range, the axis of the bore may be pointed as far to the left of the target as the shot would drift to the right.

12. **Range tables.** Range tables set forth in a convenient form certain facts pertaining to the trajectory in air. Issued herewith is a range table for the 3-inch gun, while in Ordnance Pamphlet No. 1033 and in the respective handbooks may be found range tables for all field artillery weapons in the United States service. These range tables are based, in all cases, on proving ground firings. The meaning of the headings of the columns, when considered in connection with the definitions given in Par. 1044, D. & S. R. for F. A. is in most cases obvious.

Looking at the three columns headed "Range" for shrapnel, "Range" for shell, and "Angle of Departure," it is seen that the muzzle velocity for shell is less than for shrapnel while approximately the same range is obtained with the same angle of departure. This is because of the greater ballistic efficiency (due to shape, etc.) of the shell as compared to the shrapnel.

The "Angle of Elevation" is given in degrees and minutes since it might be convenient in that form if the necessity should arise for laying the gun for elevation with a quadrant graduated in those units.

The values given under the headings "Angle of Fall" and "Slope of Fall" are different ways of expressing the same thing, that is, the final inclination of the trajectory with respect to the plane of site, which, in this case, is the horizontal plane. A slope of fall of, say 1 on 10, means that the tangent to the trajectory at its point of fall drops 1 yard vertically to every 10 yards horizontally.

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The column headed "Range change due to 1 mil of elevation" gives the change in range to point of fall due to a change of one mil in the elevation or angle of departure. A value of 25 for 2400 yards means that when firing at 2400 yards a variation in the elevation for this range of one mil would change the range of the trajectory 25 yards.

Corrector 30 is the corrector setting which should, under normal conditions, give normal heights of bursts. As a basis for constructing the fuse setter for the 3-inch gun, the Ordnance Department has adopted a height of burst of 3 mils as the normal. The fuse setter is so constructed that if a shrapnel be fired with its fuse set at a given range and at this normal corrector, it will burst under normal condition, not at the range used, but sufficiently short of this range to place the burst, as viewed from the firing point at the normal height above the point of fall of the trajectory. The use of this normal corrector and any particular range should then under normal conditions, result in air bursts at normal height. Now if the range remain unchanged but the corrector be raised one point above the normal, the bursts should be in air and higher than those with the normal corrector. They will not, however, for all ranges, be 1 mil higher but will vary from a point of burst 1 mil higher as the angle of fall and as the remaining velocity vary. Since these two variables tend to compensate, the values of 1 point of corrector, except for short ranges, differ but slightly from 1 mil in height of burst. A change of corrector does not affect the trajectory, therefore the burst range with raised corrector will be less than the burst range with normal corrector and by the amounts tabulated in the column headed "Change in burst range due to 1 point of corrector."

Example: A shot is fired from a 3-inch gun with the following data:

Site 305; corrector 33, range 2500, and a height of burst of 6 mils is observed. For the next shot the corrector is 28, the rest of the data remaining the same. Theoretically by how many mils was the height of burst lowered by this change?

Solution: For the second shot the height of burst is lowered by 5 points of corrector. The number of mils of change in the height of burst is found by multiplying the number of points of corrector change by the ratio of the change in burst range produced by one point of corrector to the range change produced by one mil of elevation at the given range. From the range table the value of this ratio is 19/25. Therefore the mil change in height of burst is $5 \times 19/25 = 3.8$ m.

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Except at the very short ranges, a point of corrector may, in firing, be taken as corresponding to a mil in height of burst.

The "Drift" is tabulated in mils as measured from the firing point. No compensation for drift is included in the construction of sight mountings for field artillery weapons.

When making conversions from degrees and minutes to mils or the converse, it will be convenient to remember that:

1 mil = 3.375 minutes, exactly;
1 degree = 18 mils, very closely;
Minutes × .3 = mils, approximately.

13. The data in the range tables are calculated for fire delivered under normal conditions; normal muzzle velocities, projectiles of normal weight and shape, normal atmospheric conditions, no wind, and with horizontal planes of site. Under normal conditions the propelling charge of a round of ammunition should move the projectile from the muzzle at its normal velocity. The higher the temperature of the charge the more rapidly the powder burns, and the greater the pressure behind the projectile in the bore. An increase in the temperature of the charge, therefore, increases both the muzzle velocity and range, and vice versa.

14. **Atmospheric influences.** The range of the projectile and the time of burning of the powder train in the fuse are influenced by atmospheric temperature and pressure. Moisture in the air has a negligible effect.

For a constant barometer, the lower the temperature, the shorter the range; the higher the temperature, the longer the range.

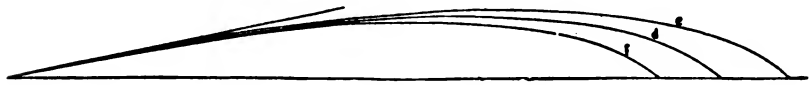

FIG. 38.

(1) Change of range caused by change of atmospheric temperature.
d—Trajectory with normal temperature.
e—Trajectory with increased temperature.
f—Trajectory with decreased temperature.
(2) Change of range caused by change of atmospheric pressure.
d—Trajectory with normal pressure.
e—Trajectory with decreased pressure.
f—Trajectory with increased pressure.

For a constant temperature, the lower the atmospheric pressure, or barometer, the longer the range; the higher the pressure, the shorter the range. In a high altitude, where the pressure is low, the range is long.

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In summer, when the temperature is high and the barometer low, the range is long; in winter, when the temperature is low and the barometer high, the range is short.

In each case all three trajectories have the same angle of departure.

An accelerating wind increases the range. A retarding wind has the opposite effect.

The lower the temperature, the more slowly the time train of the fuse burns; the higher the temperature, the more rapidly it burns.

The lower the pressure, the more slowly the time train burns, the higher the pressure, the more rapidly it burns.

The effect of atmospheric conditions upon the height of burst of shrapnel fired with certain instrumental settings is a resultant of the effect of those conditions upon the flight of the projectile and upon the burning of the time train. Hence the corrector setting required to produce a normal height of burst under given conditions, in other words the "normal corrector," depends for its value upon the above mentioned components.

The lower the temperature, the higher the corrector setting required to obtain a normal height of burst; the higher the temperature, the lower the required normal corrector.

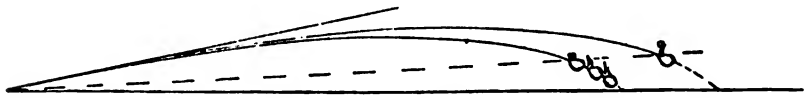

FIG. 39.

g—Trajectory and normal height of burst for a certain temperature.
h—Trajectory and height of burst for a decreased temperature, considering the effect of temperature on the trajectory only.
k—Height of burst considering effect of decreased temperature on both trajectory and time of burning.
m—Position to which burst must be brought to give normal height of burst. Both trajectories have the same angle of departure.

The lower the pressure, the higher the corrector setting required to obtain a normal height of burst; the higher the pressure, the lower the required normal corrector. In a high altitude, a higher normal corrector is required because the pressure is less and the height of burst, for a given setting, is thereby lowered.

Both trajectories have the same angle of departure.

The above figures are not drawn to scale; the variations shown are diagrammatic and not exact.

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In summer the corrector setting required to obtain a normal height of burst is low, in winter it is high. The effect of a high altitude upon the height of burst may be either decreased or increased by the effect of temperature variations.

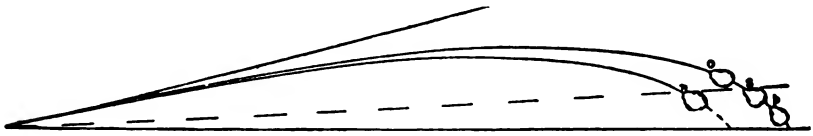

FIG. 40.

n—Trajectory and normal height of burst for a certain pressure.
o—Trajectory and height of burst for a decreased pressure considering the effect of pressure on the trajectory only.
p—Height of burst considering effect of pressure on both trajectory and time of burning.
s—Position to which burst must be brought to give normal height of burst.

Variations in range and height of burst caused by atmospheric conditions increase with the range. (Par. 1225, D. and S. R.)

The battery commander will, under ordinary circumstances, be informed of the atmospheric conditions, and this will allow him to correct for the same and open fire with more accurate initial data; nevertheless, whenever observation of fire on the target is possible, these corrections do not permit him to omit the adjustment of fire which must always be made.

Shrapnel Action

15. Shrapnel action. When a shrapnel bursts on its trajectory, the bullets are driven forward from the shrapnel case in a cone-shaped group called the **shrapnel cone.** The apex of the cone is at the point of burst and its axis is tangent to the trajectory.

The bullets leave the case with the remaining velocity of the projectile plus the increment of velocity, about 274 feet per second for the 3-inch gun, imparted by the action of the base charge; both of these acting in a direction tangent to the trajectory. They also have a velocity perpendicular to the trajectory because of the projectile's rotation. The relative values of the velocities in these two directions together with the interference of the bullets with one another determine the amount of their divergence. The angle of extreme divergence at the apex of the cone is called the **angle of opening.** This angle increases slightly with the range, but with the 3-inch gun it may be taken practically as constant for all ranges, and equal to 15°.

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16. Ground pattern. A cross section of the shrapnel cone would show the bullets to be fairly uniformly distributed; the pattern of the shrapnel on the terrain, however, shows a distribution of the bullets which is not uniform on account of the fact that the shrapnel cone is usually inclined to the terrain, the inclination varying with the angle of fall and the slope of the ground.

Assuming the height of burst to remain normal, as the range increases the depth and width of the ground pattern diminish

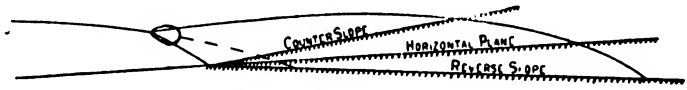
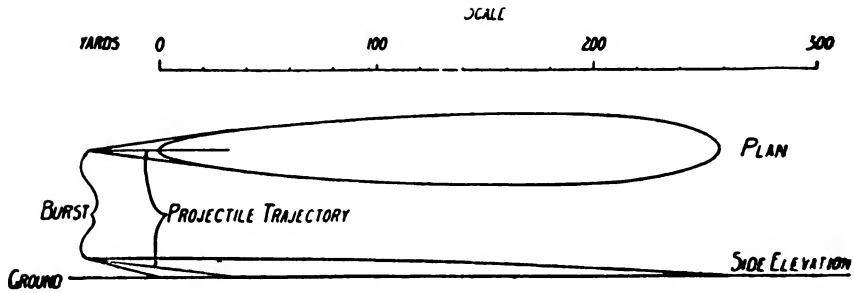


FIG. 41.



GROUND PATTERN 3 INCH GUN
RANGE 3000 YARDS HEIGHT OF BURST 3 MILS

FIG. 42.

rapidly, the depth and width of the effective pattern also diminish but more slowly, while the number of effective balls increases. Also, as the height of burst increases, the ground pattern becomes larger and the density of bullets in the pattern becomes less.

Figure 41 shows how the depth of the pattern varies with the slope of the ground.

Figures 42 and 43 represent the ground patterns of a 3-inch gun shrapnel and a 6-inch howitzer shrapnel, respectively. In the ground pattern, the bullets will be found to be most dense a little short of the point of fall of the trajectory, the density of the bullets in the far end of the pattern being quite small. In the figures, the trajectories of the extreme bullets are shown as straight lines, whereas, of course, the trajectories of all the bullets are really curves.

17. Effect. The effectiveness of a shrapnel bullet depends on its weight and on its striking velocity. It is considered that a striking energy of 50 foot-pounds will in general be disabling in the case

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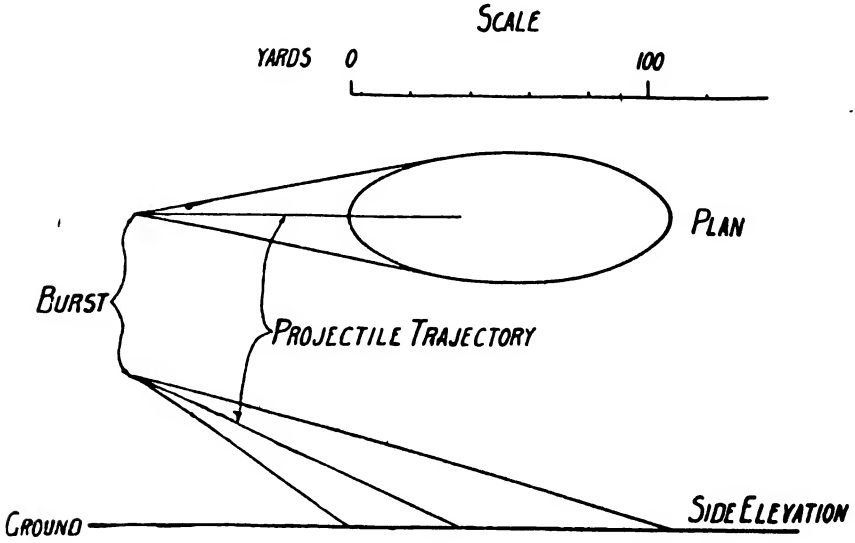
of personnel. On account of the spherical shape of the bullets they rapidly lose their velocity during flight. For the 3-inch shrapnel, the bullets of which average 42 per pound; when fired at range 3000 yards, the limiting range of effective bullets is about 275 yards. However, on account of the small number of bullets in the far end



GROUND PATTERN 6INCH HOWITZER
RANGE 5000 YARDS HEIGHT OF BURST 10 MILS
FIG. 43.

of the pattern, the effective pattern is usually considered to be not more than 150 yards in length. The width of the effective pattern of well adjusted shrapnel is taken as 20 yards if one round is fired, and 25 yards if two are fired.

18. The normal height of burst is that at which the projectile is most effective. For the 3-inch gun at mid ranges this is usually considered to be about 3 mils as measured from the gun. It will be found, however, to vary with the character of the target and with the range, as well as, of course, with the weapon used.

19. At the longer ranges, percussion shrapnel has little effect; at the shorter ranges, however, where the angle of fall is so small that the shrapnel ricochets and bursts a little above the ground, it is effective against non-sheltered personnel.

Shrapnel has also an incendiary effect.

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Probability

20. All the problems treated up to this point have had definite answers. We come now to a class of problems whose answers are uncertain—problems each of which may have one of several outcomes. For example, if three coins are tossed into the air, how many will fall with heads up? It is impossible to give a certain reply; there may be three, two, one or no heads. The best that we can do is to indicate the likelihood of each combination.

Definition of Probability.—If in a large number, N, of trials an event happens L times, the probability, p, that the event will happen is defined to be

$$p = L/N.$$

For example, if 150 shots are fired at a target and 85 fall within 40 yds. of it, the probability that a single shot will fall within 40 yds. of the target is 85/150 or 17/30. In other words, the event happens in 17/30 of the cases.

The probability of an event expresses what will happen in the long run. The probability should therefore be based upon as large amount of data as possible.

It is sometimes possible to tell *a priori* what the probability is. Thus if we wish to know the probability of throwing a head in tossing a coin, we easily convince ourselves that in view of the symmetry of the coin, heads are as likely to fall as tails; that in the long run heads will be about half of the total number of trials. The probability of throwing a head is then 1/2. In most practical cases, however, the probability can only be determined by a large number of trials.

If p is the probability of an event, the probability that the event will not happen is 1 − p.

For if the event happens L times out of N, it fails to happen N − L times. The probability of not happening is

$$\frac{N - L}{N} = 1 - \frac{L}{N} = 1 - p.$$

If an event always happens its probability is 1; if it never happens its probability is 0.

This follows at once from the definition of probability.

Mutually Exclusive Events.—Two or more events are **mutually exclusive** if no two of them can happen at once. Thus throwing a head and throwing a tail with a coin are mutually exclusive events.

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Similarly, in firing at a target, an over and a short are mutually exclusive events; whereas an over and a right are not mutually exclusive, since both can occur at once.

If p_1 and p_2 are the probabilities of two mutually exclusive events the probability that ONE OR THE OTHER will happen is $p_1 + p_2$.

For example, if one shot in ten strikes a certain portion of the target and one shot in twelve strikes the remaining portion, the probability of hitting the target is 1/10 + 1/12, or 11/60. That is, eleven shots in sixty on the average will strike one or other of the two portions.

Independent Events.—In the preceding case, the happening of one event excluded the happening of the other. If, on the other hand, the happening of one event has no effect upon the happening of the other, the two events are said to be **independent.** For example, an over and a right are independent events; for the fact that a shot is over does not influence its lying to the right or left of the target.

If p_1 and p_2 are the probabilities of two independent events the probability that BOTH will happen is $p_1 p_2$.

For example, if the probability of an over is 1/2 and the probability of a right is 1/2, the probability of both an over and a right is 1/2 × 1/2 or 1/4. That is one half of the shots are over, and one half of these, or one fourth of all, are also to the right.

Even if the events are not independent, $p_1 p_2$ is the probability of both happening, if for p_2 we take, not the original probability of the second event, but the probability that the second event will happen when the first is known to have happened.

Exercises

1. If 125 shots are fired at a target and 70 of them fall within 25 yds. of it, what is the probability that a single shot will fall within 25 yds. of the target?

Ans.: etc. 14/25.

2. If eight men in a hundred in the army are illiterate, what is the probability that a soldier you meet can read and write? Ans.: etc. 23/25.

3. In pistol practice, if one shot in fifteen strikes the bull's-eye, and one out of eleven scores 9, and thirteen out of twenty strike the remaining portions of the target, what is the probability of a single shot missing the target?

Ans.: etc. 127/660.

4. If when scouts are sent out for reconnaissance, one in fifteen fails to return, and three out of seventeen on the average come back wounded, what is the probability that a scout will return safely? Ans.: etc. 193/225.

5. In receiving semaphore messages, a candidate misses 15% of the letters. What is the probability that he will correctly receive a word of four letters?

Ans.: etc. 522.

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Results of Several Trials.—Let p be the probability of an event and suppose two trials are made. The event may happen in both trials, or in one trial only, or in neither trial. We wish now to find what the probability of each possibility is. Let q be the probability that the event will not happen ($q = 1 - p$). Now the happening of the event in one trial does not depend upon its happening in the other, thus the rule of independent events applies. Applying this rule we see that the probability of the event happening in both trials is p^2; the probability of its happening in the first trial and failing in the second trials is pq; the probability of its failing to happen in the first trial and happening in the second is qp; and the probability of its failing to happen in both is q^2. So we have the following results:

Happening in both, Probability = p^2
Happening in one, Probability = $2pq$
Happening in neither, Probability = q^2.
A convenient way to arrange the work is as follows:

1st trial: $p + q$
2d trial: $p + q$

$$p^2 + pq$$
$$pq + q^2$$
$$p^2 + 2pq + q^2.$$

Here we have merely multiplied $p + q$ by itself. The first term in the product is the probability of happening in both; the second is the probability of happening in one and failing in one; and the third is the probability of failing in both.

Suppose that three trials are made. Continuing the process:

$p^2 + 2pq + q^2$
3d trial: $p + q$

$$p^3 + 2p^2q + pq^2$$
$$p^2q + 2pq^2 + q^3$$
$$p^3 + 3p^2q + 3pq^2 + q^3.$$

Here p^3 is the probability of the event happening in all three trials; $3p^2q$ is the probability of its happening in two trials only; $3pq^2$ is the probability of its happening in one trial only; and q^3 is the probability of its failing in all three. That each of these probabilities is correct can be verified directly. Thus, to find the probability that the event will happen twice only we note that it may

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happen in one only of the first two trials (probability = 2pq) and happen in the third trial (probability = p), the probability of this being $2p^2q$; or it can happen in both of the first two trials (probability = p^2) and fail in the third trial (probability = q), of which the probability is p^2q. The probability of one of these two exclusive combinations occurring is $2p^2q + p^2q = 3p^2q$, as was found above. Each term in the multiplication has a definite interpretation.

We can now solve the problem of the three coins proposed at the beginning of the section. The probability of getting heads is 1/2. That is, $p = \frac{1}{2}$, and $q = \frac{1}{2}$. We have then the following results

3 heads, probability = $p^3 = \frac{1}{8}$
2 heads only, probability = $3p^2q = \frac{3}{8}$
1 head only, probability = $3pq^2 = \frac{3}{8}$
No heads, probability = $q^3 = \frac{1}{8}$

The Binomial Theorem.—The procedure explained above can be used for any number of trials. If n is the number of trials, it is necessary to find the terms of $(p + q)^n$. To save the labor of carrying out the multiplication there is a general formula known as the **binomial theorem** by which the product can be written down at once. The binomial theorem is as follows:

$$(p+q)^n = p^n + np^{n-2}q + \frac{n(n-1)}{1\times 2}p^{n-2}q^2 + \frac{n(n-1)(n-2)}{1\times 2\times 3}p^{n-3}q^3 + \ldots\ldots$$

As a result of the previous discussion we can state the following theorem by the use of which all probabilities in repeated trials can be found.

Let p be the probability that an event will happen, and q (= 1 − p) be the probability that the event will not happen, and let n be the number of trials. Expand $(p + q)^n$ by the binomial theorem. Then the first term in the expansion is the probability that the event will happen n times; the second term is the probability that the event will happen n − 1 times, and fail to happen once; the third term is the probability that the event will happen n − 2 times and fail to happen twice, and so on.

We note that in any term of the product the exponent of p indicates the number of times the event happens, and the exponent of q indicates the number of times it fails to happen.

If we wish to find the probability that an event will happen **at least** m times in a certain number of trials, we add the probabilities that it will happen m times, m + 1 times, m + 2 times, etc.

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Dispersion

21. Definitions. Experience has shown that:

(1) When a certain number of rounds are fired from the same piece with the same elevation, under conditions as nearly identical as possible from one shot to another, that is, with the same atmospheric temperature and pressure, the same direction and the same velocity of wind, the same lot of projectiles and same lot of powder, the projectiles nevertheless do not fall all at the same point but are distributed in a more or less irregular manner about a certain point called the **center of impact**. This scattering of shots is called Dispersion.

The principal causes of dispersion are the variations from shot to shot in the propelling charge, weight of projectile, action of gun and mount, irregularities in laying, and the small variations of atmospheric conditions occurring from one shot to another.

The distance in the direction of range which may thus occur between the points of fall of two rounds from the 3-inch gun, range 5000 yards, may be as great as 200 yards.

(2) When a certain number of groups of rounds are fired from the same piece with the same elevation, under different atmospheric conditions from one group to the other, that is, with different temperatures and atmospheric pressures, variations of direction and velocity of wind, the centers of impact of the several groups thus fired are distributed in a more or less irregular manner about a center. This phenomenon is called the **variation of the center of impact.**

The distance in the direction of range which may thus occur between the points of fall of two rounds from the 3-inch gun, range 5000 yards, may be as great as 900 yards.

As the result of the observation and measurement of many rounds, information has been obtained concerning the laws of dispersion. In individual cases results may be obtained apparently not in agreement with these laws, but in the long run it will be found that agreement will be obtained. A method of fire which is not in agreement with the laws of dispersion may possibly in an isolated case lead quickly to the result desired, but in the long run it will lead only to a useless waste of ammunition.

22. Center of impact. Suppose a certain number of rounds are fired from the same piece with the same elevation and direction at a horizontal target.

On account of dispersion the shots will fall in a more or less irregular group. The **mean range** of shots fired may be determined by

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measuring the range to each point of fall, finding the sum of these values, and dividing this sum by the number of rounds fired. Similarly the **mean deviation** may be determined by measuring the deviation of each round from a vertical plane, parallel to the axis of the bore before firing, adding, algebraically, the deviations and dividing the sum by the number of rounds fired.

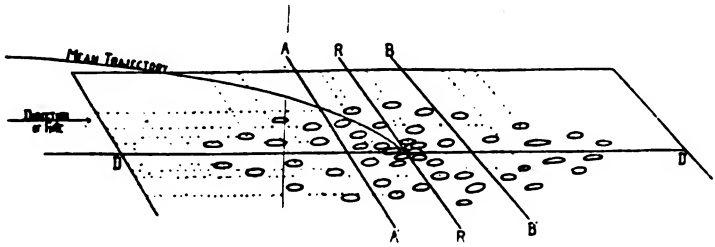

FIG. 44.

If a line, RR^1, be drawn in the horizontal target perpendicular to the vertical plane at a distance from the piece equal to the mean range, and another line, DD^1, drawn in the target parallel to the vertical plane, at a distance from it equal to the mean deviation and on the proper side, the intersection of these two lines will determine the **center of impact**, C. The trajectory passing through the center of impact is called the **mean trajectory.**

The center of impact when referred to with respect to range alone is sometimes called the **range center.**

The difference between the range to the point of fall of a particular shot and the mean range is the **range error** of the shot. Finding the range error for each shot, adding, and dividing the sum by the number of rounds fired, gives the **mean error.** In this last operation no attention is paid to whether an error is positive or negative; the numerical value only is considered. An error is positive (+) when the particular outcome of the event is greater than the mean, and negative (−) when the particular outcome is less than the mean.

It often happens that in a small number of shots one or more may occur, either erratic, or so unusual, as to be of very rare occurrence and which, if used in computations, would indicate a greater inaccuracy in the gun than actually exists. Shots of this nature should not be considered.

23. **The 50% zone.** Suppose a very great number of rounds are fired under the conditions mentioned above. It will be found

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that, with respect to range, 50% of the shots will fall beyond the line RR′, and 50% will fall short of that line. If two other lines are drawn in the target parallel to the line RR′; one, AA′, at such a distance short of RR′ that one half of the short shots will lie short of AA′, and the other half of the short shots will lie beyond this line; and the other line, BB′, similarly dividing the overshots, it will be found that 50% of the shots fired will lie in the area between the lines AA′ and BB′, and that these lines are equally distant from the center. (See Figure 17.) This area is called the 50% zone.

24. **The probable error.** The range errors of all shots lying within the 50% zone are necessarily equal to or less than ½ the width of this zone, and the range errors of all shots lying outside this zone are necessarily greater than 1/2 the width of this zone. One half the width of the 50% zone is equal to the **probable error.** The probable error is the error which, in the long run, would be as often exceeded as not. In other words, each of the probabilities, namely, the probability of exceeding this error and the probability of not exceeding this error, is 50%.

25. **Centers.** The remarks made above with reference to the manner of determining the mean error, the probable error, zones, etc., for dispersion with respect to range, apply equally well to dispersion with respect to lateral deviation, or as it is usually called, deflection.

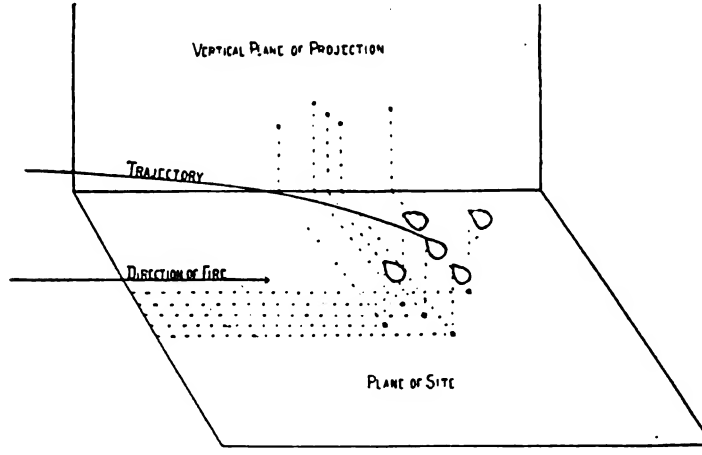

Fig. 45.

They also apply in the case of the dispersion which would be shown by shots fired at a vertical target such as might be used at the shorter ranges.

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The same methods may be used in determining the probable error with respect to range and height of burst in the case of air bursts.

Suppose a number of shots are fired under similar conditions, all bursting in the air. The point about which the bursts are evenly distributed is called the **burst center.** By projecting the points of burst into the plane of site, points will be obtained from which may be calculated the mean burst range; similarly, by projecting the points of burst into a vertical plane parallel to the plane of fire, points will be obtained from which may be calculated the mean height of burst in feet or yards.

In determining the center of impact in the case of bursts in air, it is necessary to determine the point of fall of each shot by extending its trajectory to the plane of site.

Considering the dispersion with respect to range alone, the center of impact is called the **range center;** with respect to deflection alone, the center of impact or the burst center, as the case may be, is called the **deflection center.** In the case of air bursts, considering the dispersion with respect to range alone, the burst center is called the **range-of-burst center;** with respect to height of burst alone, the **height-of-burst center.**

It must be understood that the location of a center determined by a limited number of shots is more or less in error. A center can be exactly located only by an infinite number of shots.

26. Probable error tables. The probable error table shown below was obtained by carefully considering all available rounds fired at service firing at the School of Fire for Field Artillery during 1913, 1914, and 1915.

This firing was executed under varying conditions of weather, ammunition, personnel, etc., and consisted of over 5000 rounds fired in nearly 500 problems, all with the 3-inch gun. The duration of fire which enters into the data from which this table was prepared was taken as the time ordinarily required to attack one objective; therefore the variations due to changes of atmospheric conditions during the fire could not have been great. The quantities in this table give various values of the probable error of a single shot, which may be considered as representative and suitable for studying questions of firing procedure.

In this table, the values of the range-of-burst probable error and of the height-of-burst probable error were obtained from an analysis of the individual range-of-burst and height-of-bust errors.

The value of the vertical probable error for any range, is obtained from the value of the corresponding range probable error by multiplying the latter by the tangent of the angle of fall.

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PROBABLE ERROR TABLE FOR THE 3-INCH GUN

Service

RANGE	PROBABLE ERROR						
	TRAJECTORY				RANGE OF BURST	HEIGHT OF BURST	
	Range, Yards	Vertical, Yards	Deflection				
Yards			Yards	Mils	Yards	Yards	Mils
1500	39	1.8	3.1	2.1	27	2.1	1.4
1600	38	1.9	3.4	2.1	27	2.3	1.4
1700	37	2.0	3.6	2.1	28	2.5	1.5
1800	36	2.1	3.9	2.2	28	2.7	1.5
1900	35	2.3	4.1	2.2	29	2.0	1.6
2000	34	2.4	4.4	2.2	29	3.2	1.6
2100	33	2.5	4.6	2.2	29	3.4	1.6
2200	32	2.6	4.9	2.2	30	3.6	1.7
2300	31	2.8	5.1	2.2	30	3.9	1.7
2400	31	3.0	5.4	2.2	30	4.1	1.7
2500	31	3.2	5.6	2.2	31	4.3	1.7
2600	30	3.3	5.9	2.3	31	4.5	1.7
2700	30	3.5	6.2	2.3	31	4.7	1.8
2800	30	3.6	6.4	2.3	31	5.0	1.8
2900	30	3.8	6.7	2.3	32	5.2	1.8
3000	29	3.9	7.0	2.3	32	5.4	1.8
3100	29	4.1	7.3	2.4	32	5.6	1.8
3200	29	4.3	7.7	2.4	32	5.8	1.8
3300	29	4.5	8.0	2.4	32	6.1	1.8
3400	29	4.7	8.3	2.4	32	6.3	1.8
3500	28	4.9	8.6	2.5	31	6.5	1.8
3600	28	5.1	9.0	2.5	31	6.7	1.9
3700	28	5.3	9.3	2.5	31	6.9	1.9
3800	28	5.4	9.7	2.5	31	7.1	1.9
3900	27	5.6	10.0	2.6	31	7.3	1.9
4000	27	5.8	10.4	2.6	31	7.5	1.9
4100	27	6.0	10.7	2.6	31	7.7	1.9
4200	27	6.2	11.1	2.6	31	7.9	1.9
4300	26	6.4	11.4	2.7	31	8.1	1.9
4400	26	6.6	11.8	2.7	31	8.3	1.9
4500	26	6.8	12.1	2.7	31	8.5	1.9
4600	26	7.0	12.5	2.7	31	8.7	1.9
4700	25	7.2	12.8	2.7	31	8.9	1.9
4800	25	7.4	13.2	2.8	31	9.1	1.9
4900	25	7.6	13.6	2.8	31	9.2	1.9
5000	25	7.8	14.0	2.8	31	9.4	1.9

The dispersion of points of impact in the direction of range will be less in the case of shots falling on a forward or a counter slope and greater in the case of shots falling on a reverse slope, than in the case of those falling on the plane of site.

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27. The errors of a battery as a whole are greater than those of a single piece, since the pieces of a battery do not, in general, fire exactly alike. The errors for a long period of firing are greater than those for a short period, since there is a wider variation of attendant conditions. Weather conditions, ammunition, and the like, affect the probable error. The probable error varies with the range. The value of the range probable error depends primarily upon:

(a) variations in the angle of departure, and

(b) variations in muzzle velocity.

An examination of the range table will show that the effect on the range of the former variation decreases as the range increases, while the effect of the latter increases as the range increases. The combined effect of the variations affecting the range, determine for any particular gun and ammunition, the value of the range probable error.

An official French publication of recent date on the subject of dispersion states that the value of the range probable error depends:

(a) on the gun, diminishing generally as the caliber is increased;

(b) for a particular gun, on the range, increasing with the range except at the shorter ranges where on account of the flatness of the trajectory, it has a greater value than at the mid ranges;

(c) for a particular gun and range, on the projectile used, generally varying inversely as the weight of the projectile and as its ballistic co-efficient;

(d) for a particular gun, range and projectile, on the propelling charge, increasing with the slowness of the powder, or what is practically the same thing, being greater with a reduced charge than with a normal one.

28. In the French field artillery, it is prescribed that the values of the probable errors as taken from the proving ground probable error table be multiplied by the factor 1.5 in order to obtain the probable errors for field service. The method used in determining the value of the factor 1.5 is not known, but it is stated that it was adopted as the result of experience.

29. The dispersion scale. The probability table may be stated in the following approximate form, which is easy to remember: If the extent of possible errors be divided into parts by nine parallel lines, equally spaced and separated by a distance equal to the probable error, with the center on the middle line, the eight parts between the lines will include practically all errors. And further, the errors will fall in the various parts, taken in order in either direction

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from the center with frequencies in the long run which are expressed by the figures 25, 16, 7, and 2 respectively. This is shown in the diagram below.

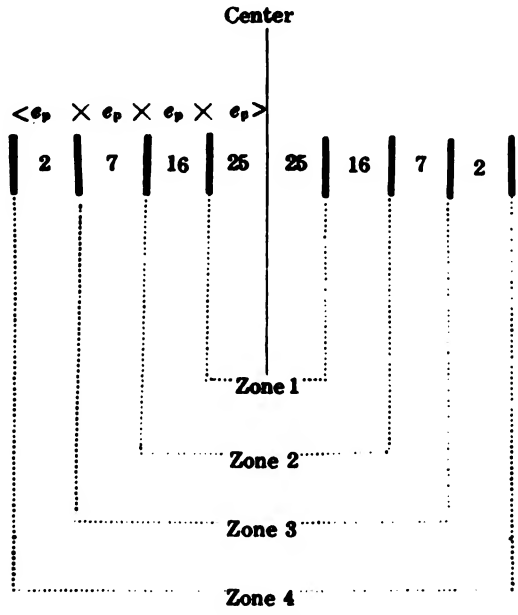

FIG. 46.

The probabilities that the error of a single occurrence of the event will be within the part to which each of the numbers shown in Figure 48 refers, are .25, .16, .07, and .02. The parts may be collected into zones and numbered 1, 2, 3, and 4 as shown in the diagram. The probability:

for zone 1 is $.25 + .25 = .50$;
for zone 2 is $.16 + .25 + .25 + .16 = .82$;
for zone 3 is $.07 + .16 + .25 + .25 + .16 + .07 = .96$
and for zone 4 is $.96 + (2 \times .02) = 1.00$.

30. In solving problems, the dispersion scale may be used.

Example: The range probable error of the 3-inch gun at range 3000 yards being 29 yards, what is the width of the 75% zone?

Solution: Referring to the above dispersion scale, it is seen that the 50% zone (25 + 25) is two probable errors wide, and the 82% zone (16 + 25 + 25 + 16) is four probable errors wide. The 75% zone will then include the 50% zone and equal portions adjacent to that zone of the two 16% strips. These two portions must be of such

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width that together they will contain 25% of the shots fired; therefore each will contain 12.5%. Assuming the dispersion in any particular strip to be uniform, which assumption is not exactly true, each portion of the 16% strip will be 12.5/16 of a probable error in width. The width of the 75% zone equals therefore 2 + (2 × 12.5/16) = 3.5 probable errors, which, since one probable error = 29 yards, is equal to 101.5 yards, the width of the 75% zone.

31. **The 25% rectangle.** The 50% zones for range and deflection having been determined, if one of these zones be superimposed on the other a rectangle will be formed which will contain 50% of 50%, or 25%, of the total number of shots. This rectangle is called the 25%, or probable, rectangle, and the size of this rectangle for different guns gives a measure of their relative accuracy.

Dispersion Diagram

Direction of fire

0.04	0.14	0.32	0.50	0.50	0.32	0.14	0.04	2.
0.14	0.49	1.12	1.75	1.75	1.12	0.49	0.14	7.
0.32	1.12	2.56	4.00	4.00	2.56	1.12	0.32	16.
0.50	1.75	4.00	6.25	6.25	4.00	1.75	0.50	25.
0.50	1.75	4.00	6.25	6.25	4.00	1.75	0.50	25.
0.32	1.12	2.56	4.00	4.00	2.56	1.12	0.32	16.
0.14	0.49	1.12	1.75	1.75	1.12	0.49	0.14	7.
0.04	0.14	0.32	0.50	0.50	0.32	0.14	0.04	2.
2.	7.	16.	25.	25.	16.	7.	2.	100%

FIG. 47.

In this figure the range probable error is taken as four times the deflection probable error. (See values for 3-inch gun for range 3000 yards.)

The 25% rectangle is indicated by heavy lines.

32. **Dispersion diagram.** Considering the dispersion scale described in paragraph 29, and supposing the scale for deflection to have been superimposed on the scale for range, a diagram similar to that shown in Figure 49 may be constructed which gives a good idea of dispersion.

33. This diagram at once suggests a method of determining the probability of hitting a target of given dimensions, not by comparing the area of the target with the area of the rectangles shown in the diagram, as many students are prone to do, but by the method used in the following example:

Example: A 3-inch gun is firing at a horizontal target the dimensions of which are 70 yards in the direction of range by 10 yards in

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width. A shot is fired; what is the probability of its hitting the target, it being assumed that the center of impact is adjusted at the center of the target and that the range is 3000 yards?

Solution: In the figure below are shown the target abcd, and the dispersion scale for range.

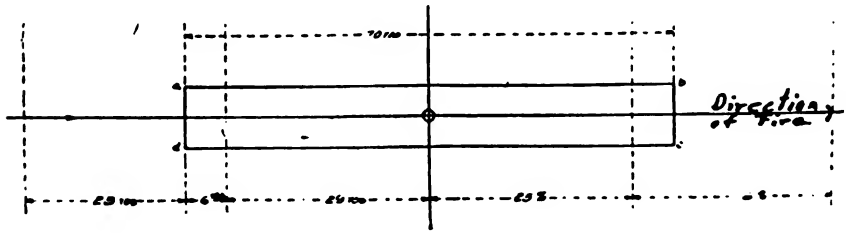

FIG. 48.

In the figure the center of impact is shown at the center of the target, which extends 35 yards on each side of this center in the direction of fire and 5 yards on each side (in deflection). In solving this problem, first determine the probability of a hit in the area of indefinite width which is bounded by the ends of the target, ad and bc, produced to the right and left and forming a zone 70 yards deep in the direction of range. From the Probable Error Table we read the range probable error for 3000 yards as 29 yards, so that both 25% strips are included in the 70-yard zone, with 6 yards left over in each 16% strip. The 16% strips are also 29 yards wide, hence 6/29 of each of the 16% strips are included in the 70-yard zone. The probability of a hit within this zone is therefore

$$.25 + .25 + .16 \times 6/29 + .16 \times 6/29 = .566$$

In the figure below are represented the target and the dispersion scale for deflection.

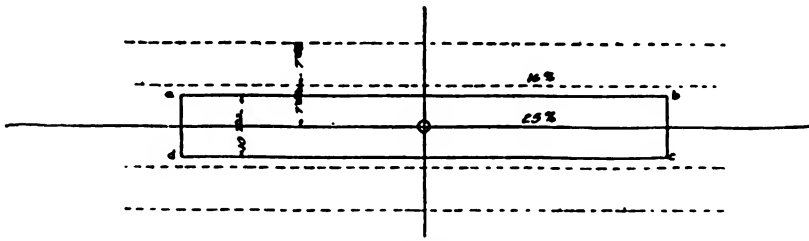

FIG. 49.

Now determine the probability of a hit in the area of indefinite depth which is bounded by the sides of the target produced in both directions, in this case, the zone 10 yards wide.

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From the figure it is seen that the zone covers 5/7 of each of the 25% strips. The probability of a hit within the zone considered is therefore

$$.25 \times 5/7 + .25 \times 5/7 = .357$$

Then the probability of the shot's hitting in both of these zones or, in other words of hitting the target, is

$$.566 \times .357 = .20 \text{ or } 20\%.$$

Example: If 200 hits are required to destroy the above target, how many rounds must be fired?

Solution: The probability of a shot's hitting the target is 20%, hence of all rounds fired, 20% are taken as hitting the target, 200 hits are to be made.

$$20\% \text{ of rounds fired} = 200$$
$$100\% \text{ of rounds fired} = 1000 \text{ (Ans.)}$$

34. Variation of the range center. In the statement defining dispersion (par. 21) it will be remembered that the shots were supposed to have been fired under conditions as nearly identical as possible from one shot to another that is, with the same atmospheric temperature and pressure, the same direction and the same velocity of wind, the same lot of projectiles and the same lot of powder. During the time consumed in firing at a single objective in service practice, say two or three minutes, these conditions are realized to a greater or less degree. But when the firing extends through, say several hours, atmospheric conditions may change to such an extent as apparently to increase the dispersion. This increased dispersion is in reality a combination of the dispersion proper and the variation of the position of the center of impact. Suppose that several groups of shots be fired as stated in paragraph 21 (2), say different groups on different days under different atmospheric conditions. It will be found that for each group the dispersion will be substantially the same, since the atmospheric conditions of the moment will affect the trajectories of all shots of a group in practically the same manner, but the positions of the centers of impact of the several groups may be widely separated. When spoken of with reference to range alone the variation of the center of impact is called the **variation of the range center.**

If, by means of the range tables, the firing data are properly corrected for the atmospheric conditions of the moment, a reduction in the effect of the variation of the center of impact may be expected.

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Based on extensive experience with the 3-inch gun at the School of Fire during 1913, 1914, and 1915, the probable variation of the range center has been determined to be:

Range Yards	Probable Variation Yards of Range
2000	50
3000	67
4000	80
5000	90

It is therefore seen that at range 5000 yards, under extreme conditions the range centers of two groups of shots fired with the same elevation might be as far apart as $8 \times 90 = 720$ yards.

Then too, because of dispersion, a shot of each of these groups might strike $4 \times 25 = 100$ yards from the center of impact of its group and on the side away from the other group, so that it would be possible for two shots fired from the same piece with the same elevation under extreme conditions to strike $720 + 100 + 100 = 920$ yards apart. This is illustrated below.

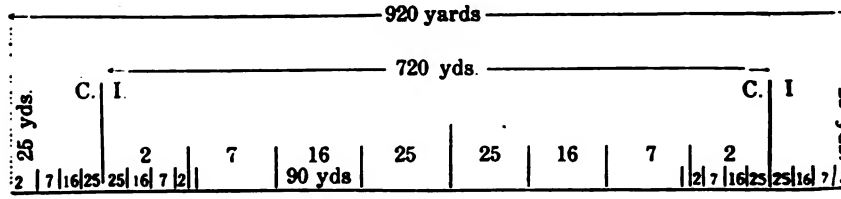

FIG. 50.

35. Determination of the Probable Position of a Center with respect to a Target. When observations of overs and shorts have been made at the same range, it is possible to determine approximately how far the range center is beyond or short of the target. The appropriate change in range can then be made to bring this center on the target, so that the numbers of shorts and overs will be equal. The range will then be adjusted exactly. In like manner, observations of a number of lefts and rights with the same deflection setting permit the determination of the approximate distance that the deflection center is to the right or left of the target. Observations of air bursts above and below a target permit a like calculation for the height of burst center. It is not necessary to know the exact distance from the target to these bursts.

Example: At a range of 3000 yards, a 3-inch gun fires a salvo which

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results in three shorts and one over. What is the most probable position of the range center with respect to the target? In other words, what range change should be made in order to obtain an equal number of shorts and overs?

Solution: The range center must be short of the target, since if it were at the target equal numbers of shots would have fallen short and over. Now since 50% of the shots fired at any target are assumed to fall over the range center, and since in this example 25% fell over the target, then 50% − 25% = 25% of the shots fell between the target and the range center. The target, then, is on the edge of the 25% strip in the dispersion scale (Par. 30), the width of which is one probable error. The range probable error at 3000 yards is 29 yards. Therefore the range center is 29 yards short of the target, and an increase of 29 yards in range is required to adjust the range perfectly.

36. Solution of Problems. The solution of a problem in one dimension (range in this case) is explained in paragraph 35. Simple two-dimension problems are solved in paragraph 33. Problems in which the target has three dimensions, length, width, and height, can be solved most readily by considering that the shots were fired at a target determined by projecting upon a single plane the different surfaces of the blockhouse which could be hit. An examination of Figure 51 shows that the problem can then be solved as a two-dimension problem.

Example: With a 3-inch gun battery firing at range 3600 yards, what per cent. of shots will hit a blockhouse 10 yards wide, 3 yards high, and 10 yards deep in the direction of range, assuming the plane of fire to be perpendicular to the front face of the blockhouse and the center of impact adjusted at the middle of the lower edge of this face?

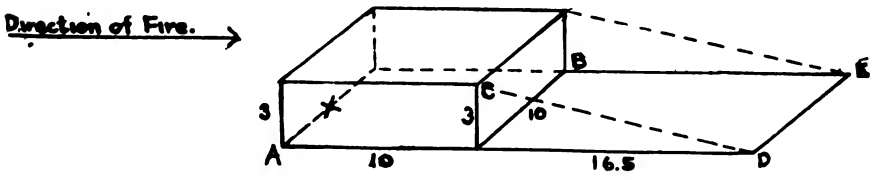

FIG. 51.

Solution: The center of impact is at the cross-mark. The base, AB, of the target equals the top. The back face (CB) is equal to the front face and its projection the same size. The slope of fall at range 3600 yards is 1 on 5.5, therefore the vertical face CB offers a target

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equivalent to the horizontal target BD, 10 yards wide and $3 \times 5.5 = 16.5$ yards deep. The cubical target is equivalent to the horizontal target AE.

The problem is now solved by placing the dispersion scale for 3600 yards upon the rectangle AE, as in paragraph 34, with the center of impact at X.

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CHAPTER VII

CONDUCT OF FIRE

CONDUCT of Fire consists in so employing the weapons at hand as to cause fire of the desired nature to be brought to bear upon the target. Study Part 3 D. & S. R. F. A.

Whenever the target can be seen the laying of the guns should be corrected according to the observation of the bursts with reference to the target. When no observation station is available it is then necessary to use maps to get the firing data. Every effort should be made to observe the effect of fire and recourse should never be had to map firing except when observation fails. Observation is of two kinds, terrestrial and aerial. Firing with aeroplane observation will not be considered in this book.

The targets attacked are of two general classes; fixed or stationary, and moving. A trench is an example of a fixed target. A column of infantry on the march presents a moving target.

Since the exact range to give hits on the target cannot be determined before firing the attack on the target is divided into two parts; fire for adjustment and fire for effect. In fire for adjustment the officer firing the battery attempts to determine the range that will give shots surely short of the target and a second range that gives shots clearly beyond or over the target. The difference between these two ranges is in general known as a bracket, and the target is located between the two ranges. By firing at a range halfway between the two, the target is located in the nearer half or farther half of original bracket. By continuing this halving process the range is found that will give best effect on the target. From this point on the firing is called fire for effect, and has for its object the destruction of the target or the silencing of its fire. When the opening range has been determined by range finder the first range change should be a jump of 200 yards. If the range has been estimated the approximate change is 400 yards.

Since speed in the adjustment is not required, the attack of fixed targets will be considered first. The beginner will have no thought

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of limited time to worry him and he can give his full attention to deliberate firing. The method of firing has been adopted from the French and is called Percussion Precision Fire. To get effect on material objects very accurate adjustment in both range and deflection is necessary in order to place shots at or in close proximity to the target.

This fire is effective at all ranges but because the probable error in deflection increases and observation becomes more difficult, to get effect at the longer ranges requires the expenditure of much ammunition. The adjustment in range is never completed, but is carried on to the end of fire for effect. In order to increase the accuracy of adjustment, fire for adjustment is usually conducted by piece, each gun being adjusted individually upon its part of the target.

In Percussion Precision Fire, fire for adjustment is divided in two parts, trial fire and improvement fire. These are followed by fire for effect.

As stated above in fire for adjustment a system of bracketing is carried on to determine the best range for each gun. In trial fire instead of using the term bracket fork is used. A fork is 4 field probable errors and varies in size at different ranges.

Our regulations have always used the word "bracket," qualifying it by of "100 yards," of "200 yards," etc., as the case called for. From our probable error tables we see that 100 yards means approximately 4 field probable errors for the 3-inch gun. In the new publications the word bracket is still used, but it is now qualified by the words "of so many forks." A one-fork bracket is synonymous with our 100-yard bracket, a fork being exactly 4 field probable errors for any range. Range changes on our 3-inch gun are limited to approximately 25 yards, but the guns used in Europe permit the use of brackets or forks of varying size since the ranges or elevations may be set off in degrees and minutes, or in twentieths of degrees, allowing very small range changes. Range changes with these guns will not be the same at different ranges, because instead of changing, as we do, by 4 forks of 100 yards (400 yards), 2 forks of 100 yards (200 yards), or one fork of 100 yards, the range changes are by 4, 2, or 1 actual forks which are exactly equal to 4 times the field probable error for any range. In like manner it is possible to change a range (elevation) by exact fractions of a fork, instead of being limited to 25-yard changes.

Trial Fire is conducted by firing one round at each range, and is carried on until a bracket of one fork is obtained, with two observations at each of the limiting ranges. The mid-range of this bracket is called the TRIAL ELEVATION or TRIAL RANGE. Initial range bounds

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of 4, 2, or 1 forks are made, depending upon the accuracy with which the initial data was determined. (N. B. These range bounds coincide with those used in time fire, axial observation.) Two rounds are habitually fired at the center of a two-fork bracket, since this elevation will in all probability be one limit of the one-fork bracket sought. If during Trial Fire a short and an over are observed at the same range, *i. e.*, a contradiction, two more observations at the same range are necessary. If the second two observations are in the same sense, *i. e.*, both short or both over, the range is taken in this sense, and a range bound of one fork made. If, however, the second two observations fired after the contradiction was obtained, are again opposite in sense, the elevation is bracketing and is taken as the Trial Elevation. If during Trial Fire a round is observed to hit the target, it is counted as two observations, one over and one short, and must be treated in the same manner as one over and one short obtained from two rounds fired at that elevation.

Fire for Improvement is begun at the Trial Range, where 12, 8, or 6 observations are sought, depending on circumstances. If an equality of shorts and overs is obtained at this range, it is called the Adjusted Range. If there is not an equality of shorts and overs, modify the range by as many twelfths, eighths, or sixths of the fork as there are sensings to be changed to obtain this equality. This change for the 3-inch gun is limited to multiples of 25 yards. The change will bring the center of impact of the piece near the target, so that the numbers of shorts and overs will be approximately equal. The range thus obtained is called the Adjusted Range and is used in fire for Effect.

In Improvement Fire of 12 rounds per piece, a series of 6 rounds is first fired. If the first series yields observations both short and over, the second series is fired at the same elevation. If, however, the first series of six observed rounds are in the same sense, all shorts or all overs, the range is changed by a half fork and six more rounds are fired. If this second series yields one or more observations in the opposite sense from those obtained in the first series, all 12 observations are taken as having been fired at the mean of the two ranges used, and the correction in twelfths is referred to this mean range. If the last series of six rounds are all observed in the same sense as the first six, Trial Fire is again undertaken. However, the range last fired is taken as one limit of the new bracket being sought, and a range change of one fork is made. Example: 6 rounds, 3050 + + + + + + 3000 + + + + + + 2 rounds, 2900.

Note.—One fork bound from 3000 to 2900, and 2 rounds fired at 2900.

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In Improvement Fire a target hit is counted as one half short and one half over, and all observations obtained are doubled.

Example: 3050 + — — + — T
3050 + — — — + +

Five and one half over and six and one half short = 11 over and 13 short.

Change by one twenty-fourth of a fork.

If Improvement Fire is undertaken immediately after completion of Trial Fire and at the same range last fired in Trial Fire (*i. e.*, when the trial elevation is determined as the result of a verified contradiction), all rounds fired without an intervening change in elevation will also be counted as observations obtained in Improvement Fire. In any other case, observations obtained during Trial Fire cannot be utilized as observations in Improvement Fire. If in firing the first series of six rounds it is impossible to get six observations for range, and of the observations obtained there are opposite sensings, enough rounds must be fired in the second series to bring the total number of observations up to twelve.

After the Adjusted Range is obtained for Number 1, the deflection, site, and range are recorded at the gun, which ceases firing at the command, "Adjusted Range (so and so), cease firing, record data." If the guns are not calibrated, that is, if no correction for variation in range between guns can be made, fire is now opened with Number 2, obtaining two observations at the adjusted elevation of Number 1, and Trial Fire by one-fork range changes is carried on. When the Trial Range for Number 2 has been obtained, Improvement Fire is begun. All pieces are adjusted in like manner.

When the calibration error for the guns is known, the following method is used for bringing in the second gun. Start fire with the second gun at the adjusted range of the first, corrected for the calibration error. Two observations are made at this range. If these observations yield opposite sensings, that range is taken as the trial range and improvement fire is begun without verifying the contradiction. If the two observations are in the same sense, a range change of one half fork is taken in the proper direction, and trial fire is carried on as in the usual case.

Fire for Effect. After the adjusted Elevation or Range has been obtained for each piece, Fire for Effect is begun. The Adjusted Range is only approximate and must therefore be observed for a sufficient number of rounds to determine surely the range for the target which gives an equal number of observations short and over. Moreover, this range for the target is constantly subject to change

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on account of the heating of the pieces and other causes, so that practically constant observation during Fire for Effect is necessary.

During Fire for Effect battery salvos should be used with whatever interval is necessary, usually one or two seconds. Firing is by series of 24 or 48 rounds. During the fire the observer notes the sense of each round and at the end of the series reports the result as a whole. Based on this report corrections are made, if necessary, to obtain an equal number of shorts and overs. Corrections for the battery as a whole are made when the number of rounds observed in Effect is at least equal to the number observed from a single piece in Improvement Fire. Individual corrections are made only when the number of rounds observed for the piece corrected is at least equal to the number observed during Improvement Fire with that piece. When the fire becomes faulty, the observer makes a point of ascertaining whether a particular piece is responsible or whether it is due to the battery as a whole.

In the former case the elevation of the piece is corrected and fire by series is resumed. If the piece cannot be corrected, it ceases firing and fire for Effect is continued with the rest of the battery. If the fault is due to the battery as a whole, the adjustment must be begun anew. Fire is continued until the desired result is obtained.

Special Cases, Remarks, Commands

Deflection Adjustment. If the initial deflection is seriously in error, make a change for the battery to bring the whole sheaf on the target. Then proceed by individual corrections for one gun only.

Bold deflection changes should be made at first to obtain rapidly a deflection bracket. The deflection changes are then measured, each burst being sensed for deflection. When the deflection deviation is not more than 4 probable errors (3 mils is taken as a sufficiently accurate value for 4 deflection probable errors), the deflection is not changed until several successive and concordant shots show it to be advisable. In this case make a change equal to the mean of the several deviations observed.

Deflection adjustment and range adjustment are conducted simultaneously when the bursts are near enough to the target to permit observation for range.

Problem in Percussion Precision Fire or Demolition.

Commands.	A. P., flag pole, direct rear. Deflection 3200 On No. 1 close 5	**Sensings.**

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Site 305	
Percussion	
Number 1 only	
2000	50 right, doubtful
Left 50, 2000	5 left, doubtful
No. 1 right 5, Nos. 2, 3, and 4 will not follow, 2000	3 right, short
2400	2 right, over
2200	2 right, over
2 rounds, 2100	4 right, short 2 right, short
Left 2, 1 round, 2200	1 left, over

The verified bracket is 2100–2200, and the Trial Elevation is 2150. This completes **Trial Fire.**

6 rounds at 5 seconds, 2150	Short, over, over, over, short, over
2150	Over, short, over, over, over, short.

This completes **Improvement Fire.** Observations, 8 overs, 4 shorts. Two of the overs must be changed to shorts to obtain an equality. Therefore decrease the range by 2–12 of the fork, or 2–12 of 100 yards = 16 yards. Nearest change with 3-inch gun is 25 yards, therefore Adjusted range or elevation is 2125 yards.

Adjusted range 2125, cease firing, record data.	
Number 2 only, 2 rounds, 2125	10 left, doubtful 8 left, doubtful
Right 10, 2125	2 right, short 1 left, short
2225	2 left, over, 1 right, over.

Trial Elevation 2175.

Having completed Trial Fire, take up Improvement Fire with twelve required observations, as with Number 1.

All guns being adjusted, No. 1 at 2125, No. 2 at 2150, No. 3 at 2100, No. 4 at 2175.

Battery right, 6 salvos at 5 seconds.

No. 1, 2125; No. 2, 2150; No. 3, 2100; No. 4, 2175.

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Moving targets are not likely to remain long exposed either to view or to fire. To get the center of impact of each gun on its part of the target takes time and so percussion fire cannot be used. The ranging is ordinarily done with shrapnel. Stationary targets such as a battery in position are attacked with shrapnel.

Unless the target is of great depth, there is one range which will produce the greatest effect on the target wherever it is in the bracket. Most effect is produced by shrapnel when the target is at the point that would be hit by the graze projectile on the trajectory. At midranges the effective sweep of shrapnel is 3-mil burst -40 to $+85 = 125$ yards.

Battery salvos are normally used if fire for effect is to be by battery. This is the most rapid method of ranging. By piece is the most economical of ammunition.

Grazes are measured from the bottom of the smoke ball. Bursts are measured from the top of the burst to the bottom of the target, and zero bursts, except at a range under 2000 should be below the top of the target. The diameter of the burst is about 4 yards.

One observation surely over is sufficient for a range change. A sure over is a graze or a burst of any height giving effect over. One observation surely short is sufficient for a range change.

A sure short is a graze or zero height of burst short. A burst may be sensed short when the effect is all or nearly all short. When firing to determine a 200-yard bracket one short and one over are accepted as sufficient to warrant going into fire for effect. For a 100-yard bracket, 2 shorts and one over are necessary. During the adjustment the deflection should place center of impact of the sheaf on the center of the target. The height of burst should be zero or half the shots should burst on graze and half in the air.

For targets in which immediate effect is necessary, estimate the range and determine a 400-yard bracket that includes the target. Walk through this bracket rapidly. For rapidly moving targets estimate the range, make jumps of 600 yards or 800 yards in range until the target is located in a bracket. Go through this bracket and include 200 yards more in the direction of movement.

The term bracketing is used in reference to the deflection and corrector. Bold changes in deflection and corrector should be made in the early adjustment.

In fire for effect the bracket is covered in 100-yard increments. By observation during effect the ineffective ranges can be eliminated, and the bracket cut down so that only ranges are used which give effect on target.

Never use a range longer than the long limit of the bracket.

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It is best to use the long limit of a 100-yard and eliminate later, and also for 200 yards unless there have been 2 sure overs.

For a bracketing salvo go into fire for effect at that range and observe. As long as effect is plainly at target continue that range. When the effect is not at the target change the range in the appropriate sense by 50 yards.

A mixed salvo is the best indication of a 100-yard bracket. Fire at that range and include a range 100 yards short or over according as salvo was mixed over or short. Fire two volleys at the range that gave the mixed salvo for every volley at the range 100-yards from that.

For the height of burst if last salvo for adjustment gave two air and two graze, go up three for effect; if one air and three graze, go up five; if three air and one graze, do not change corrector.

So much for the discussion of firing by observation. The other phase of firing is the preparation of fire by map. Map firing has been in use in the Allied armies for a considerable time and our artillery is thoroughly familiar with its methods. Its accuracy, however, is never sufficient to permit other than zone fire, *i. e.*, searching a depth to cover possible errors.

Obviously, under these conditions annihilation or destructions are hardly possible. The ammunition expended is great, but this is possible because of great concentrations of artillery and because the necessary ammunition for an initial attack can be accumulated beforehand. Map firing is also of great advantage at night or in fog when no observation is possible. It is always advantageous to use it when time permits, to afford a first close approximation for observed fire, thus shortening the adjustment. It follows that map firing has a permanent and important place in artillery activity and must not be neglected or belittled.

Map Firing

1. The first steps in computing firing data by maps are:

a Locate the exact position of the directing piece.

b Locate the exact position of the aiming point.

c Locate the exact position of the B. C. station.

2. Reading the Deflection.

Let G be the directing piece, P the aiming point and T the target, on a battle map or cross-section map. Draw straight lines GT and GP, and measure, by means of the protractor, the angle P G T.

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Read from the line PG to the line GT as shown in figure, counter clockwise. This angle is the Deflection.

3. Determination of the Range.

Measure the distance G T on scale of map (1-20000 on battle map or 1-50000 on cross-sectioned map), recording it as yards or meters. This distance is the Map Range.

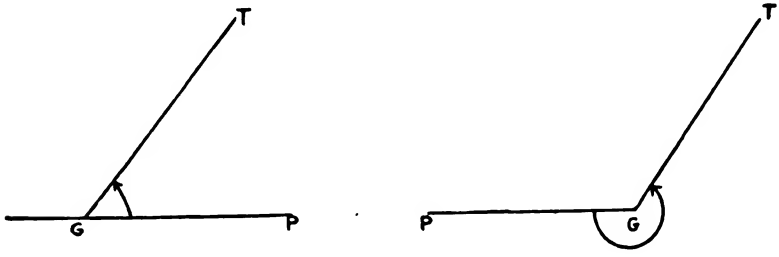

FIG. 1.

4. Determination of the Angle of Site.

Read the elevations of G and T, in yards or meters, and obtain the difference. Divide difference in elevation by map range (4). If T is above G add to 300 (horizontal), if below G subtract from 300. The result is the Site.

5. Importance of Accuracy.

Accuracy in the use of maps is extremely important. Computations with the 1-20000 map or the 1-50000 map should be so accurate that searching and sweeping fire (zone fire 200 meters short and over the target and 15 miles right and left) can be opened without preliminary fire for adjustment. Since the target is usually invisible, adjustment for more accurate fire must be carried on with aircraft observation. The computations must be so accurate that the first salvo, falling near the target, may be observed. This is important for rapidity, and when a number of batteries are firing, it is absolutely necessary in order to distinguish the bursts from your battery from those of other batteries.

6. Methods of Obtaining Accuracy.

a The position of the directing piece and of the aiming point must be marked with a very fine small cross and surrounded by a small circle to aid in identification, and the lines GT and GP must be carefully drawn in fine lines.

b The range GT must be read to within twenty-five meters or twenty-five yards.

c The angle PGT must be measured to within ten mils. Take great care to place the origin of the protractor exactly on G and the

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zero edge exactly along the line GP. It is well to place on the paper the face of the protractor on which the graduations are cut. In case the angle PGT is greater than 3200 mils, read the smaller angle at G and subtract from 6400.

d Great care in reading contours lines and in interpolating between them is necessary. The slope of the ground is closely observed in interpolating. An error of five mils in the angle of site means a great error in range, and also makes corrections of the moment inaccurate.

In modern warfare the necessity for concealment of the guns places them very frequently in a position where there are no aiming points visible. Batteries are placed in woods where they are screened from observation by aeroplanes. They are placed in ravines or in folds in the ground. As in the war in Europe where there were heavy mists and frequent hard rains all possible aiming points were obscured. In order to lay the guns under such conditions recourse is had to compass laying.

1. Very accurate compass laying requires the use of a prismatic compass, graduated to read in mils, and a tripod for steadiness. Any compass may be used, however.

2. The Magnetic Variation of a Compass.

In compass laying, all angles are measured on the compass from the magnetic north, indicated by the direction of the needle. Compass needles vary slightly in direction, and the magnetic north varies from the true north. These variations are different in different localities. Before a compass can be used in connection with artillery work in any locality, its magnetic variation (from the true north) must be determined for that locality.

This may be done as follows. Select a position which is clearly marked on the map and from which can be seen three distant objects, widely separated if possible, which are also clearly marked on the map. Be careful that no metal is near which might effect the needle. Lay out the map on the table and mark the selected point by a fine cross. Draw through this cross a line paralleled to the true North and South line found on the map, and rays to the three indicated points. Place a protractor with its center on the selected point and the 0-3200 mil or 0-180 line coinciding with the North and South line, 0 to the North. The number of mils at which the rays cut the protractor scale are the **True North Bearings** of the three objects.

Now set up the compass at the selected point and read carefully the Magnetic Bearings of the three objects. Suppose the following are the sets of bearing.

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True North Bearing. Read with Protractor.	Magnetic Bearing. Read with Compass.	Variation.
To A. 1268 mils.	1574 mils.	306 mils.
" B. 3713 "	4002 "	289 "
" C. 6069 "	6365 "	296 "
	Total Variation	891 mils.
	Mean "	297 "

This mean variation may be taken as the local magnetic variation, of the compass used. If the compass bearings are larger than the true north bearings the magnetic north is west of the true north and the variation is west. If the variation is compared with the declination given on the map of the locality, the difference is the error of the compass and can be marked on the compass for future reference.

3. To Find a Magnetic Bearing on a Map with a Protractor.

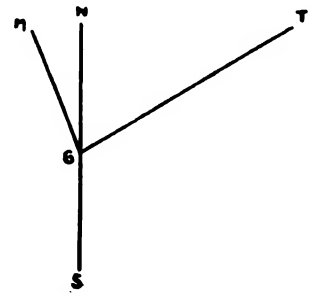

FIG. 2.

Locate accurately the gun position (G) and the target position (T) and join them by a straight line. Draw a true north-south line (GN) through G. Place the protractor on the map with the 0–3200 mil line of the protractor along GN and the center on G. Mark off on the map (M) the number of mils the compass varies from the true north, east or west. (West in paragraph 2.) Join M and G making a magnetic north-south line through G. Now place the zero line of the protractor long GM and read the angle MGT, obtaining the magnetic bearing of the target.

4. To obtain a Deflection by using a Compass and a Suitable Aiming Point.

Set up the compass about 100 yards from the guns, so that the needle lies exactly along the 0–3200 mil line, and read the magnetic bearing to the target, obtained in paragraph 3. Then read the magnetic bearing to the aiming point. The difference between the bear-

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ings indicates deflection, as shown in Fig. 3 and 3A and B. Care must be taken in case the magnetic north is between GT and GP

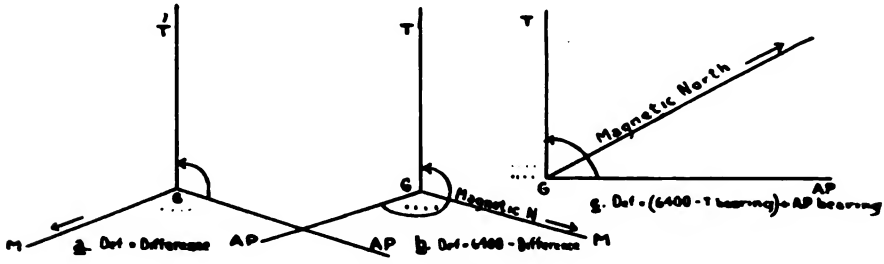

FIG. 3 AND 3A.

Fig. 2-C. Curved lines indicate deflection. Necessary corrections must be made for aiming point offset and target offset.

5. To Form a Paralleled Sheaf, Using a Compass as an Aiming Point.

In case no aiming point is visible from the guns, the executive may designate his compass as the aiming point. He sets up his compass at some point from which he can see the guns and so that the needle coincides with the 0–3200 line. The compass must be at least 50 yards from the guns so that the steel of the guns will not deflect the compass needle. In Fig. 4 and 4A, the compassis in front of the line of guns. The executive receives the true north bearing from the B. C., and changes it to the magnetic bearing of his own compass. He then reads this magnetic bearing to obtain the direction of the target. Next he sights foresight-backsight on the panoramic

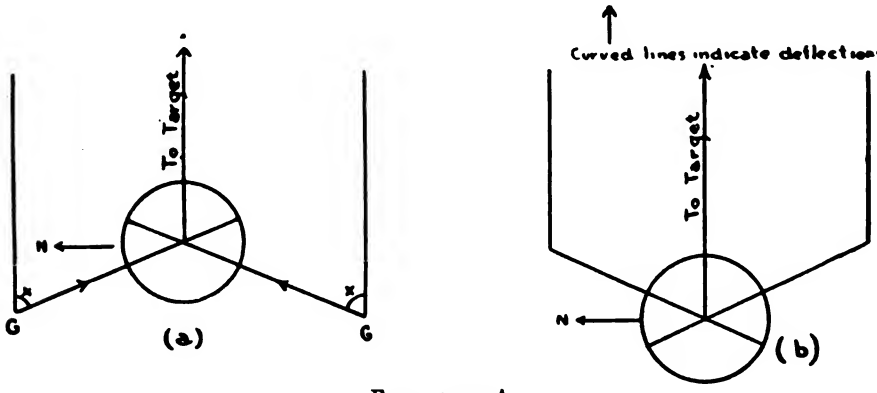

FIG. 4 AND 4A.

sight of the gun without moving the compass, and reads the magnetic bearing from the gun to the compass. This is done by sighting directly on the gun and adding or subtracting 3200 mils. By de-

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ducting this bearing from the deflection he obtains the angle x. Gun on the right of the compass will be laid x mils to the right of compass, the deflection being 6400-x., gun on the left x mils to the left, the deflection being x. In Fig. 3-B the compass is behind the line of guns. In this case the executive reads the bearing from the gun to the compass, as explained in Fig. 3-A, and subtracts the target bearing. The result is the deflection to be used by gun on right or left, your compass being aiming point.

The Barrage

The barrage, a well-known phase of map firing, is one of the developments of the present war that seems at first to be something new and difficult, but which in reality is something simple and merely a development of methods which have been in use for a long time. The barrage is, in simple terms a wall of fire set up along some given line at which it is desired to hold the enemy, and is of two kinds, namely the defensive barrage and the rolling barrage.

The defensive barrage is established on a line designated by the higher artillery commanders, each battery being assigned its part of the line. As far as the battery is concerned, the barrage is simply continuous fire at a given range and with sufficient shifts in deflection to cover completely the front assigned. The data for the barrage is all worked out in advance, and each gun has a table or schedule which it follows in the firing of the barrage, coördinating it with the other guns in such a manner that there are no spaces in the barrage line through which the enemy may pass without being subjected to fire. The main purposes of the barrage are to check the enemy attack by forming a continuous curtain of fire as close to our lines as possible, limited by the safety of our infantry, and also to prevent the arrival of reserves brought to feed and sustain the attack.

The light artillery, three-inch or seventy-five mm., has as its main function the establishment of the barrage. All other considerations are secondary. Nevertheless artillery of all calibers, including trench mortars take part in the barrage. Data must be calculated in advance, so that the battery will be ready to take its part in the barrage upon a given signal, which is usually given by the infantry which is in need of support. The barrage must then be started as soon as possible, and continued as long as the infantry has need of it. In some cases it is agreed between the artillery and the infantry that the barrage is to continue for a definite period of time and then cease if a renewal is not called for.

The rate of fire for the defensive barrage must be such that it can be continued for long periods of time, and usually does not exceed

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six rounds per gun per minute for five minutes, or about one hundred shots per gun per hour. The rate of fire is rapid at first and gradually slows up until the guns are firing about two rounds per gun per minute. If another barrage is called for while a previous barrage is being fired, the barrage is begun again, the result being an increase in the rate of fire. From time to time during the slower parts of the barrage, the guns are dropped out in turn for cooling and the other guns are shifted to cover the sector.

High explosive shell are more often used than shrapnel in the defensive barrage. Shrapnel except when fired with fuses set at safety requires a larger interval between the line of barrage and our own troops, and the height of burst must be kept well adjusted.

The line of the barrage is quite often not a straight one, in which case the battery commander must assign portions of the line to each gun. If the lines of the enemy are very close to our own, the battery commander may post his guns in such a way as to enfilade the enemy line, taking advantage of the fact that the deflection probable error is not as great as that of range.

The barrage table is calculated to give a burst about every fifteen yards along the line. This may require quite small shifts at the longer ranges, and the French gun is much better adapted to these than the three-inch, as one turn of the traversing handwheel of the French seventy-five shifts the direction about two mils, while with the three-inch gun one turn shifts eight mils.

If an accurate map of the battery sector is available, the barrage is figured out from the map, the ranges for the guns and the shifts from base deflection being recorded. But this map determination is always checked by firing, and the stripped data found.

Stripped data is the data which would give the results just obtained by adjustment on a normal day, without wind, weight of the projectile normal, etc. The method of fire used is firing volleys of a given number of rounds, sweeping, at a given rate of fire. If the battery sector is wide the guns may sweep quickly across their respective sectors, leaving spaces in the barrage uncovered by fire, then sweep back to the right with a shift of deflection calculated to place the rounds in the spaces left uncovered in the previous sweep.

It is quite important that the battery be ready to fire the barrage at any time of the day or night, and for the night firing illuminated aiming posts should be provided. These may be improvised by the use of small incandescent lights placed in a row, five mils apart, at the aiming post, the current being supplied by dry-cells.

The rolling barrage is used to accompany troops advancing to the attack, and is intended to hold the enemy to his shelters and

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prevent them manning the fire steps of the trenches and bringing up supports from the rear. Like the defensive barrage, the rolling barrage must be executed in close coöperation with the infantry. The attacking troops stick closely to the barrage, keeping about two hundred yards behind the center of impact. The average rate of advance is about 100 meters in three minutes.

The day and hour of the attack are not usually given out until shortly before the attack is to occur, but the data is figured for a day which is called "Z" day (British) or "J" day (French). The hour is designated as "H" hour (British) or zero hour (French).

The barrage table is figured out by the battery commander in accordance with his orders from higher commanders as to rate of advance, where the barrage is to stop, rate of fire, etc., and a copy of the schedule for each gun is posted in its emplacement, or recorded in the record and data book of that gun. In the firing of the rolling barrage the same methods are used as in the defensive barrage, except that range changes are added. Guns are rested and cooled in the same way. The main difference between the barrage and any other kind of firing is that the data is all figured out in advance of the actual firing. Time to do this is available in the ordinary case in position warfare.

NOMENCLATURE, CARE, AND USE OF FIRE CONTROL INSTRUMENTS

Introduction

1. Fire control instruments are **instruments of precision.** That is the reason they are used for the measurement of angles instead of depending entirely upon rough estimation by the eye or by calibrating our hands, and the like, or depending on a B. C. ruler.

2. Since their reason for existence is as instruments of precision, they must be

(a) carefully handled and kept in adjustment; and

(b) accurately and exactly used:

or they will not serve the purpose for which they exist.

Care of Instruments

3. Rules for the care of the instruments.

(a) Protect from jars and strains whenever possible.

(b) Never force any part which sticks; the same rule which

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applies in handling all matériel applies with double emphasis here.

(c) All clamps should be loosened when placing an instrument in the case.

(d) Always keep clean, and especially free from surplus oil.

(e) Working parts must be kept well lubricated, but never use enough oil to run into the body of the instrument and get into the lenses.

(f) Give especial attention to the lenses. Remove dust only with a camel's hair brush; moisten the lens with the brush and wipe dry with a piece of linen or optical cloth or paper; never use dirty cloth, chamois skin, or waste for cleaning lenses. Never moisten a lens except with the breath. Be especially careful to remove at once any drops of perspiration or finger prints, as perspiration eats into the optical surface.

(g) Keep all joints tight and never allow the seals around the lenses to be broken. If drops of moisture accumulate inside the telescope, as they sometimes will, do not take the instrument apart, but put in a warm room and moisture will dry out.

(h) If it becomes necessary to remove the lenses return tc Ordnance Department for that purpose.

(i) Always keep the instruments in adjustment, especially the angle of site measuring element, and the range adjustment on the range finder.

(j) Keep backlash or lost motion out of instrument so far as possible. This is usually accomplished by throwing the adjustment worm more tightly against the wheel by turning an eccentric bushing in which the worm is set or by tightening up a spring which bears against the worm

Battery Commander's Telescope. (1915 Model.)

Uses:

1. Angle Measuring.
2. Observation.

Tripod:

1. Legs:
   (a) Lower Legs.
   (b) Locking Screws.
   (c) Upper Legs.
   (d) Leg Clamps.

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2. Head:
   (a) Head Proper.
   (b) Head Bushing.
   (c) Vertical Spindle Clamping Screw.

Mount:

1. Ball and Socket Joint.
2. Clamping Lever.
3. Leather Dust Guard.
4. Azimuth Mechanism:
   (a) Azimuth Clamp Support.
   (b) Lower Plate (Non-reading):
      (1) Azimuth Clamp (Fast motion).
      (2) Azimuth Adjusting Worm (Slow motion):
         (a) Backlash and adjustment for; flat spring.
      (3) Azimuth Scale.
   (c) Upper Plate (Angle Measuring):
      (1) Azimuth Release (Fast motion).
      (2) Azimuth Worm (Slow motion):
         (a) Backlash and adjustment for; coiled spring.
5. Leveling Device:
   (a) Bubble Case.
   (b) Vial.
6. Locking Collar.
7. Vertical Spindle.

B. C. Instrument:

1. Locking Collar.
2. Locking Plunger and Spring.
3. Elevating Mechanism:
   (a) Elevating Knob (Attached to elevating worm, which meshes with elevating worm wheel).
4. Angle of Site Device:
   (a) Angle of Site Level Vial.
   (b) Angle of Site Scale.
   (c) Angle of Site Micrometer.
      (1) Backlash and adjustment for; flat spring.
5. Telescopes:
   (a) Clamping Knob.
   (b) Interpupillary Scale:
      (1) For vertical position of Instrument.
      (2) For horizontal position of Instrument.

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(c) Eyepieces:
  (1) Solar Attachments.
  (2) Leather Covers.
  (3) Diopter Adjustment.
  (4) Cross-hair adjustment (Reticule).
(d) Tube Bases.
(e) Tubes.
(f) Hoods:
  (1) Sun Shades.
  (2) Leather Covers.

Instrument measures horizontal and vertical angles, *e. g.*, deflection and site.
(Instrument is a binocular periscope.)
Power of instrument is 10.
Field is 75 mils.

Aiming Circle

Uses:

1. Angle Measuring.
2. Plane Table Instrument.
3. Compass.

Tripod:

1. Legs:
   (a) Lower Legs.
   (b) Locking Screws.
   (c) Upper Legs.
   (d) Leg Clamps.
2. Head:
   (a) Head proper.
   (b) Head Bushing.
   (c) Vertical Spindle Clamping Screw.

Mount:

1. Ball and Socket Joint.
2. Clamping Lever.
3. Leather Dust Guard.
4. Azimuth Mechanism:
   (a) Azimuth Adjusting Mechanism (No reading):
     (1) Wing Nut (Fast motion).
     (2) Azimuth Adjusting Worm (Slow motion):
       (a) Backlash and adjustment for; coiled spring.

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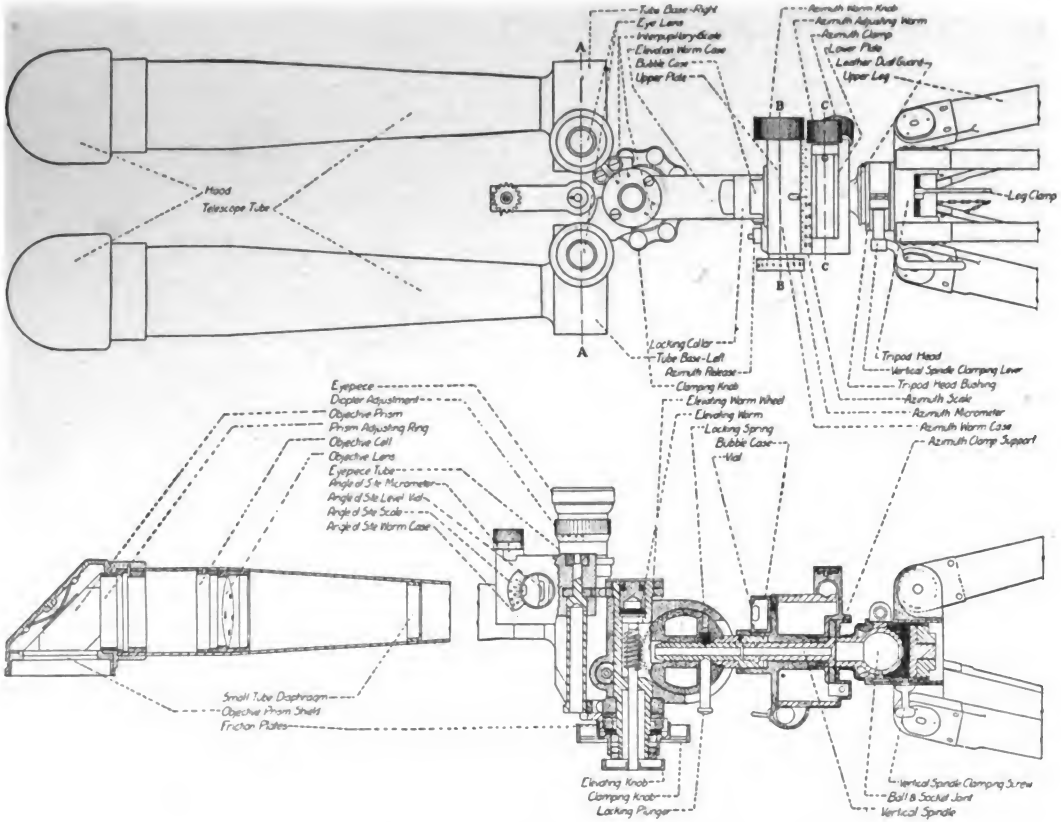
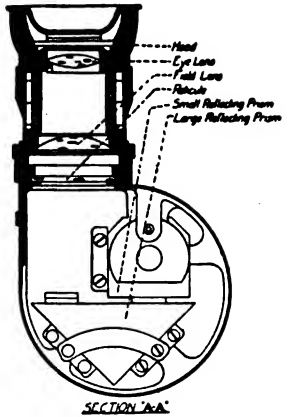
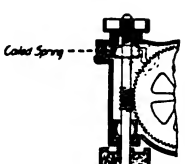
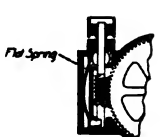




SECTION "A-A"



SECTION "B-B"
Adjustment for Backlash
Upper Plate



SECTION "C-C"
Adjustment for Backlash
Lower Plate

BATTERY COMMANDER'S TELESCOPE MODEL OF 1915

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(b) Azimuth Mechanism Proper. (Angle Measuring):
(1) Azimuth Release (Fast motion).
(2) Azimuth Worm (Slow motion):
(a) Backlash adjustment; coiled spring.

5. Angle of Site Mechanism:
(a) Elevating Worm.
(b) Angle of Site Level Vial.
(c) Angle of Site Scale.
(d) Angle of Site Micrometer.
6. Eyepiece (No personal adjustment).
(a) Illuminating Window.
7. Telescope Elbow.
8. Objective.
9. Compass Mechanism:
(a) Needle.
(b) Needle Release.
10. Centering Bubble.
11. Stand for plane Table Work.
Power—4.
Field of 180 mils.
Measures horizontal and vertical angles; *e. g.*, deflection and site.
Used also instead of an alidade for accurate plane table work.

Site Adjustment; Two stake, known elevation, and horizon methods.

Range Finder

Uses:

1. Range measuring.
2. Angle measuring.

Tripod:

1. Legs:
(a) Lower Legs.
(b) Locking Screws.
(c) Upper Legs.
(d) Leg Clamps.
2. Head:
(a) Head proper.
(b) Head bushing.
(c) Vertical Spindle Clamping Screw.

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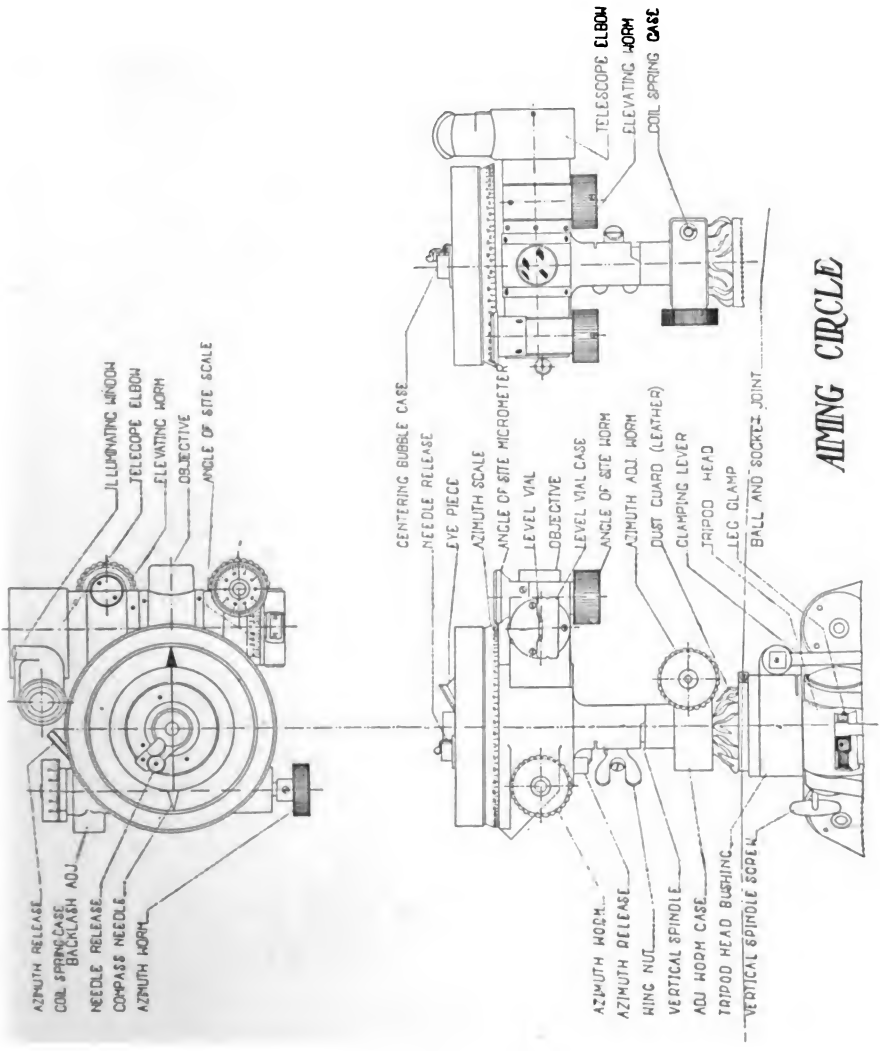

Mount:

1. Azimuth Mechanism:
   - (a) Lower Plate (No reading):
     - (1) Vertical Spindle Clamping Lever (Fast motion).
     - (2) Azimuth Adjusting Worm (Slow motion):
       - (a) Backlash and adjustment for; flat spring.
   - (b) Upper Plate (Angle Measuring):
     - (1) Azimuth Release (Fast motion).
     - (2) Azimuth Worm (Slow motion):
       - (a) Backlash and adjustment for; coiled spring.

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(c) Tilting Joint:
  (1) Locking Lever.
(d) Elevating Mechanism:
  (1) Elevating Knob.
(e) Angle of Site Device:
  (1) Level Vial.
  (2) Site Scale.
  (3) Micrometer.
(f) Lever, for Locking Range Finder in Vertical Position.
(g) Attaching Device:
  (1) Trunnions.
  (2) Spring Catch and Bolt

Range Finder:

1. Tube (Construction: Steel tube, covered with asbestos and canvas, forms outer part of the instrument. Within this is a seamless steel tube, annealed and treated to reduce effect of change of temperature to a minimum. In this steel tube are mounted the important optical parts of the instrument.)
2. Buffers.
3. Sliding Shutters.
4. Range Roller.
5. Eyepiece:
   (a) Personal Adjustment.
   (b) Ray Filter.
6. Reading Scale:
   (a) Spiral Scale.
   (b) Spiral Groove.
   (c) Indicator.
7. Range Adjustment:
   (a) Adjusting Screw.
   (b) Adjusting Scale.
8. Halving Adjustment:
   (a) Knurled Roller.
9. Open Sight.

Theory:

1. Given base and two included angles of a right triangle, to find side perpendicular to the base.
2. Base—1 meter.
   Beam through left prism forms angle of 1600 m. with base.
   Beam through right prism is deviated by turning range roller.

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Beam is deviated by lateral motion of measuring wedge.
Both objective prisms remain fixed.
Amount of movement of measuring wedge is transmitted to the Spiral Scale and mechanically graduated to read meters of range.

Adjustments:

Halving adjustment. Range adjustment, using sun, known range, and adjusting bar methods.

Use of Instrument:

Estimate range and check with Range Finder range. Use two instruments with a known distance between them and work out ranges by triangulation, by finding angle subtended at the target by the line between the two instruments. Check with Range Finder range.

Mechanical Computation of Firing Data

The process of measuring the deflection with the instrument may be briefly described as follows: Set the azimuth scale at zero. Release the base clamp and turn the telescope in the general direction of the aiming point. The vertical hair need not be adjusted accurately on the aiming point, since the only purpose of turning the instrument toward the aiming point is to make obvious the direction in which the offset will be thrown so as to be thrown away from the gun. Clamp the base, release the head of the instrument and turn it so as to carry the line of sight **toward the directing gun** through an angle equal to the aiming point offset. The base of the instrument is then unclamped and the vertical cross hair brought accurately on the aiming point. The result of this operation is to throw the zero line, from which the measurement will be made, **away from the directing gun,** by the amount of the offset angle. The base is left clamped, and the head of the instrument (that is, the telescope) is unclamped and turned toward the target and the vertical cross hair adjusted by the slow-motion screw upon the appropriate part of the target. The offset of the target having been computed, the telescope is so turned, by the use of the slow-motion screw, as to throw the line of sight away from the directing gun through an angle equal to the target offset. The deflection is then read directly upon the scale of the instrument. In case the instrument reads clockwise, the operation is reversed and the instrument is turned first upon the target.

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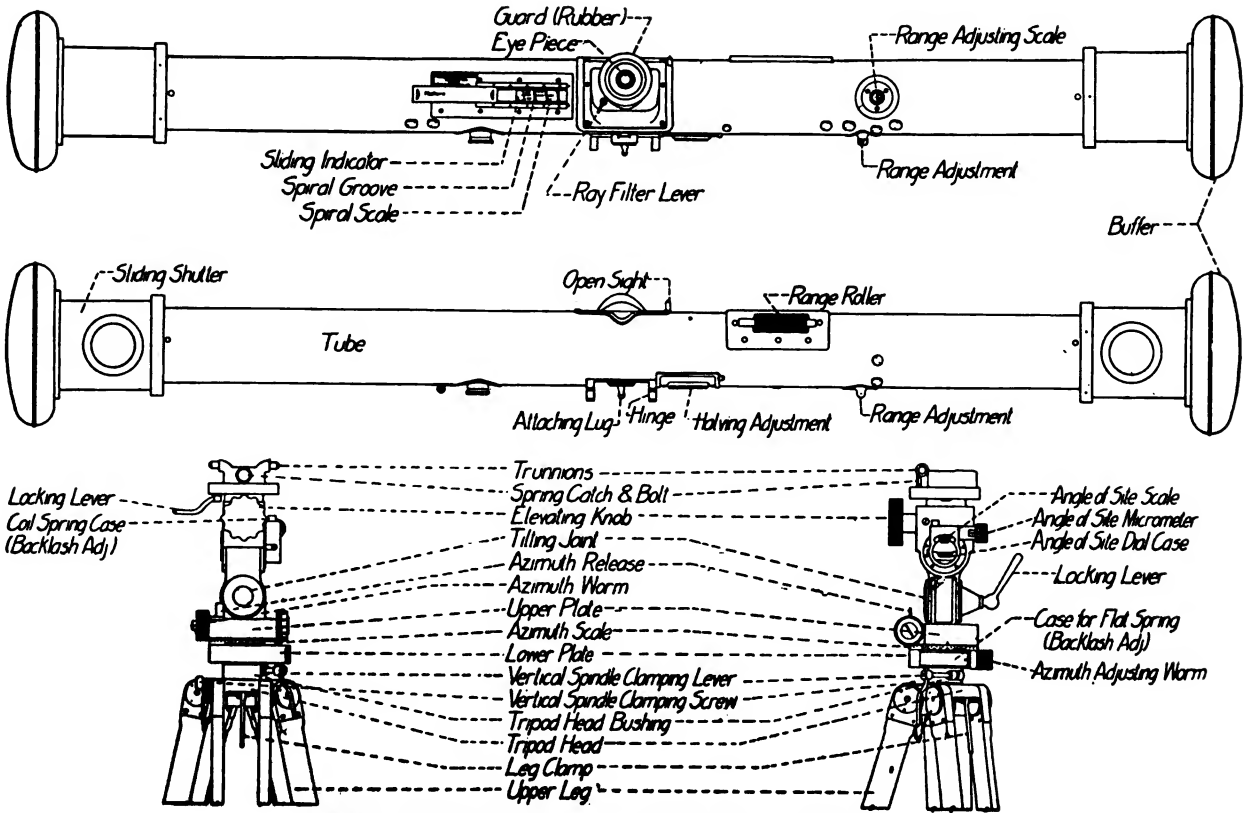

1-METER BASE RANGE FINDER

MODEL OF 1916

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Daily Assignments for Study in Conduct of Fire

The following sets of questions cover forty hours. They cover in a comprehensive way the subject of Conduct of Fire. The student who has mastered the subject sufficiently well to answer these can consider himself ready to take up the advanced work of service firing on the range.

First Hour

Pars. 833–837, 955–988, D. and S. R. F. A.

1. How are fire discipline and conduct of fire related?
2. Show by diagram four guns in position, laid with parallel sheaf on a target and using an aiming point in the left rear.
3. State and explain two methods of laying. When is each used?
4. What change takes place in the sheaf at each part of the command: Right 20 on No. 2 open 5?
5. What is meant by the directing piece?
6. State the kinds of projectile used for each kind of fire.
7. What commands designate whether bursts in air or on impact are desired?
8. For what purpose are commands for site and corrector given?
9. Write a set of commands to include deflection, deflection difference, site, normal height of burst, a salvo, and a range.
10. Define mil. What is the value of 12 mils at 1000 yards? At 400 yds.? At 3600 yards?

Second Hour

Pars. 1055–94, 1142–54, 1159–67, D. and S. R. F. A.

1. Distinguish between fire direction, preparation of fire, and conduct of fire, and state who is responsible for each.
2. What is the primary purpose of fire for adjustment? Of fire for effect?
3. When are guns posted for immediate action, in observation, in readiness?
4. Define defilade and describe three kinds.
5. State three conditions required for a good gun position.
6. State in proper sequence the data usually sent to the guns before they can fire.
7. What is a reference point? How may it be used in designating a target?
8. Give five desirable conditions of a good aiming point.
9. What is a secondary aiming point and how is it used?
10. Define sector. Who usually assigns a sector to a battery?

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Third Hour

Pars. 1155–58, 1196, 1207, D. and S. R. F. A.

1. How many mils in 30 degrees? How many degrees in 1000 mils? Ans.: 533⅓ mils, 56¼ degrees.

2. Define parallax. Compute the parallax of 400 yards at a point 2500 yards away on a perpendicular.

3. Define obliquity. Draw a circle indicating the limits of the obliquity factors, no interpolation.

4. Compute the parallax in question 2 if the point is 800 mils to the right of the perpendicular.

5. Show by diagram one gun in position (G), a target (T) 2000 yards away, an aiming point (AP) 5000 yards to the right rear, and an observing station (BC) 500 yards to the exact right of the gun. Which angle is larger, AP-BC-T or AP-G-T?

6. By parallel lines, construct an angle at BC equal to AP-G-T.

7. What is deflection? From what is it measured, and in what direction?

8. How close to their computed values are the initial deflection and deflection difference usually sent to the guns?

Fourth Hour

1. Of what line is the target offset a parallax? The aiming point offset? When are they equal?

2. In what direction are offsets always set off? Why?

3. How is an offset computed?

4. For what gun is firing data usually computed? What is this gun called?

5. Your B. C. station is 500 yards to the right flank of the line of guns. Standing at the station, you estimate the distance to the AP as 5000 yards and to T as 2500 yards, and measure the angle A (AP-B. C.-T) as 3215. Draw an accurate diagram of the problem showing the two offsets. What is the exact deflection? What deflection is sent to the guns? Ans.: 2915 mils. 2910 or 2920.

6. If your B. C. station in question 5 had been on the left flank and the measurements the same, what would have been the exact deflection? Ans.: 3515 mils. 3510 or 3520.

Fifth Hour

1. From what line do you measure the angle which determines the obliquity factors used in computing the AP-offset?

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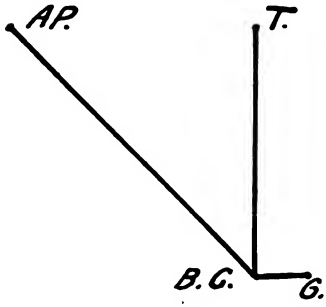
2. For what do obliquity factors correct? What do they correct?

3. How many mils in the angle "7:30 o'clock?" "2 o'clock?"

4. What angle is changed by the amount of offset? If you see this angle increased by an offset, is the offset added or subtracted?

5. Your B. C. station (B.C.) is 300 yds. to the left flank on the line of guns. At the station you make the following measurements: B. C.-AP 4000 yds., B. C.-T 2500 yds., angle A 3730 mils. What is the computed deflection? What deflection is sent to the guns?

Ans.: 3917. 3920.

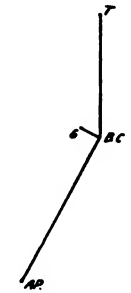


6. The AP in question 4 is shot down before your commands are sent to guns, so you must use a secondary AP, for which the angle A is 5600 mils. You estimate distance to this AP as 3500 yds. What deflection is sent to the guns? Ans.: 5660

Sixth Hour

1. When does the obliquity factor for the target equal 1? For AP equal 0?

2. If B. C.-T lines is 1450 mils off normal to B. C.-G line, what obliquity factor is used in computing the target offset?



3. Define convergence difference, distribution difference. May each be called deflection difference?

4. Define sheaf. Show by diagram (a) convergence difference, AP being in rear, (b) distribution difference, AP on left flank, T 30 mils wide.

5. What is the deflection difference for parallel fire?

6. When is the parallax of a platoon front at AP positive? Negative?

7. From the B. C. station the target is at 12 o'clock, distance 3000 yds. Guns at 10 o'clock, distance 200 yds., AP at 7 o'clock, distance 4000 yds. Compute exact deflection. Ans.: 3623 mils.

Seventh Hour

Pars. 972–975, 1208–1210. D. and S. R. F. A.

1. What parts of the initial data determine the elevation of the guns?

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2. Define site. What is meant by site 320?

3. Who sets the site in direct laying? The range? In indirect laying?

4. If your commands are "Deflection 3400, on No. 2 open 10," what is the deflection reading on each gun?

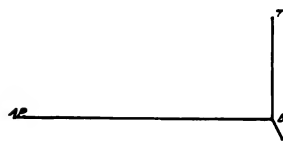
5. Define range. How far can the 3" gun shoot?

6. What is a quadrant?

7. When do the guns of a battery use different sites? What command is used for this?

8. If the B. C. is far from the guns, what is his usual command to fire?

9. Show by diagram a gun (G) on a horizontal line (GH), a target (T) 3000 yds. away and 60 yds. (TH) below the horizontal. How many mils in angle T-G-H?



10. At B. C. station you measure angle A 4800, angle G-B. C.-T 2700, distance to AP 5000 yds., to T 2000 yds., to G 500 yds. What deflection and deflection difference are sent to the guns for open sheaf?

Ans.: (a) 4990 mils. (b) On No. 2 open 10.

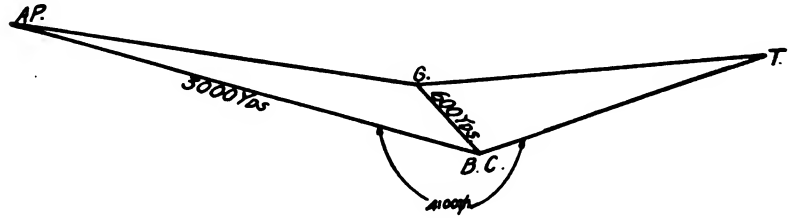
Eighth Hour

1. On rolling ground, what is the site of the distant horizon?

2. In what respects do the calculated deflection, deflection difference and site vary from those sent down to the guns?

3. The map tells you that the guns are at an altitude of 515 feet, the target at 705 feet, the range is 4000. What is the site?

Ans.: 310.



4. From the B. C. station you make the following readings:

Si to T 290, B. C. to T 3500 yds.

Si to G 275, B. C. to G 200 yds.

How many yards is T below B. C.? G below B. C.?

5. From the figure determine deflection. Ans.: 3720.

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6. Determine DD from figure (5) for parallel fire, converged fire and distributed fire over a 50 mile front.

Ans.: On No. 2 close 5, (b) close 15. (c) Zero.

Ninth Hour

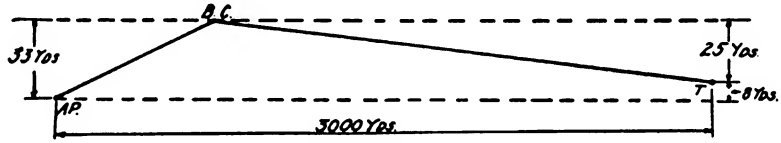
1. Your deflection is 3800, what obliquity factor is used in computing DD? State one other factor needed in computing deflection difference.

2. What does the command "Corrector (so much)" call for?

3. What is a volley? A Salvo? Give command for battery salvo, wind from right?

4. At the B. C. station you wish the following measurements: Angle A 650 mils, guns at 7:30 o'clock, distance to AP 6000 yds., to G 600 yds., to T 2500 yds., site to G, 245, to T, 290. Wind is from the left, target is a hostile battery. Give complete commands for firing?

Ans.: AP—Def. 720, On No. 2 open 10, site 305, Kr. 30, B. R. 3000.



Tenth Hour

Pars. 989–96, 1003, 1215–24, 1227–58.

1. Define fire for adjustment. State four elements to be adjusted. What general method is used in adjusting?

2. Name and explain four methods of fire. Which is best for fire for adjustment?

3. Exactly what is a bracket in range? In deflection? In height of burst?

4. What is the correct height of burst for (a) adjustment? (b) effect? Why?

5. State five requirements of good field glasses. When is it best to observe without glasses?

6. Between what two points is the height of burst measured?

7. When is a burst sensed as graze, below, graze below, low, normal, high, very high?

8. How may we distinguish between burst on impact and burst in air?

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9. If bursts 3 mils high are obtained over three different targets at ranges 2000 yds., 2500 yds., and 3200 yds., are they the same distance above the targets? If not, by how much do they differ?

10. What is a "bold change"? Of what assistance is it in obtaining a bracket?

Eleventh Hour

Pars. 1259–1280, 1283–1287, D. and S. R. F. A.

1. When is a salvo short? Over? Bracketing? Mixed?

2. Name in order of accuracy the four bases of sensing shots for range.

3. Show by diagram the reason why a sensing of "normal over" is permissible and one of "normal short" is not.

4. Where are bursts best placed so as to aid certainty of sensing when a cross-wind is blowing? A wind down the range? When sensing on a crest? When the target is in soft, swampy ground?

5. When is a sensing of "lost over" permissible?

6. Show by diagram the relative positions of sun, smoke-ball and target when a shot may be sensed from its shadow as "over"; as "short." Which of these cases is modified by the height of burst?

7. State three effects which artillery may produce other than "hitting the target."

Twelfth Hour

1. Define maximum ordinate. At what point on the plane of site is it measured?

2. Define angle of departure and state the angle of departure for 500 yds., 1000 yds., 2000 yds., and 3000 yds.

3. If a gun is fired with a range setting of 2500 yds., how far will the projectile travel before descending to the plane of site? If the angle of departure for 2500 yds. is 70 mils, how many mils has the projectile dropped in 2500 yds.?

4. Define site and quadrant elevation. What effect upon the height of the trajectory above the horizontal has an increase of site? A decrease of site?

5. You are on a crest 500 yds. in front of a gun to which you read the site as 240. How many yards are you above the gun?

6. If the crest in No. 5 were 20 yds. higher than the gun, what would be your site reading? Ans.: 260.

7. From the B. C. station you measure angle A as 700 mils, angle G-B. C.T as 510 mils with guns to your right front. Distance

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to AP is 800 yards, to G 70 yards, to T 2000 yards. What deflection and deflection difference for parallel fire are sent to the guns?

Ans.: Def. 710; D. D. On No. 2 open 15 or 20.

Thirteenth Hour

Pars. 1168–1171 D. and S. R. F. A.

1. Define minimum range, dead space, danger space.

2. What is the minimum "factor of safety" over a crest occupied by friendly troops?

3. When guns are within 200 yds. of a crest, how may the minimum elevation to clear the crest be determined at the guns? Why not at a greater distance?

4. Why is it necessary to know the "shortest range" before selecting a position behind a crest?

5. From a given position behind a crest you fire with a quadrant elevation which just clears the crest. Show by diagram that a site of 320 gives a shorter minimum range than a site of 280.

6. Range to T 5000 yds. to mask 1000 yds., site to T, 240; height of mask 300 feet. Required: height of trajectory in mils at crest, height of mask in mils, number of yards clearance.

Ans.: 120 mils, 100 mils; 20 yards.

7. If the mask in No. 4 had been 1000 yards from the enemy, other data unchanged by how many yards would you clear or fail to clear it? Ans.: Fail by 100 yds.

Fourteenth Hour

Pars. 1283–95, 1300, 1303, 1307, 1309, 1311, 1321, 1328, 1330–31, 1339.

1. State two general divisions of artillery fire on a target and the primary purpose of each.

2. Name four kinds of adjustment. What part of the firing data refers to each kind?

3. What is a minor change? A probable error?

4. State four causes of dispersion. Can they be eliminated?

5. What is a registration mark and how is it used?

6. Having sensed bursts from all four guns, which gun determines the change in deflection or distribution to be made in order to bring the whole sheaf on the target?

In what multiples is this change first made?

7. State one advantage of observing grazes during fire for adjustment, and one of observing air bursts.

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8. What height of burst is indicated by 2 graze and 2 air bursts; 1 graze and 3 air bursts; 3 graze and 1 air burst? State an exception to the second and third.

9. What proportion of grazes should be expected during fire for adjustment?

10. What part of adjustment is most difficult? Why?

11. When is a 400 yard range bound used in adjustment? 200 yard? 100 yard?

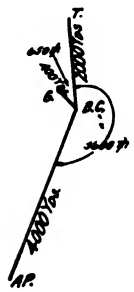
12. With the following observations, state whether the range is approximately correct, a little short, or a little long:

(a) Physical effect upon the target.
(b) Bracketing salvo on graze.
(c) Bracketing salvo in air.
(d) Mixed salvo over.
(e) Mixed salvo short, all graze.
(f) Mixed salvo, short, all air.

Fifteenth Hour

1. Make a table of angles of departure for ranges increasing by 500 yards, from 500 yards to 5000 yards, using the 1, 2, 3 method.

2. If you make the following observations on your first salvo at 4000 yards, estimated range, what is your next command?



3. From the accompanying figure, compute deflection and deflection difference for open sheaf.

ANSWER: Def. 3730. On No. 2, open 5.

4. Using figure, site to T is 285, to G 280. What is the exact site to T at range 1600? What site is used? Answer: 313.75; 315.

5. If a crest 30 feet high is in the line of fire and 400 yds. from G, by how many yards will the crest be cleared? Answer: 8 yards.

6. What is the minimum range with this site? Answer: 900 yards.

7. Give the complete data thus determined for opening fire on an infantry trench, wind from left rear.

Sixteenth Hour

1. Why do you hold your arm to the side when measuring an angle with your hand?

2. What part of your hand represents 100 mils? 40 mils?

3. What is the total width of your closed hand? Hand with fingers and thumb extended?

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4. How would you sense each of the following? Graze burst directly above target; air burst concealing target; air burst 5 mils high, effect over; air burst 5 mils high, effect short; air burst on line with target and below it.

5. In what multiples are first corrector changes made?

6. State two reasons why a 3-mil height of burst is desired during fire for effect.

7. Aiming point on right flank, target at 3000 yds. and 120 yds. wide. What deflection difference will give distributed fire?

Answer: Open 7.

8. B. C. station in line of fire, 500 yds. from guns and 3500 yds. from target. You measure site to guns as 250 and to target as 275. By how much will the projectiles clear your station?

Answer: 65 mils or 32½ yds.

Seventeenth Hour

Pars. 964, 1283–1320, D. and S. R. F. A.

1. What is the purpose of adjustment in deflection? In distribution?

2. State an aid to relocating an object in the field which is difficult to see.

3. How is the size of shift in direction determined when changing from one target to another?

4. Who orders changes of deflection in direct fire?

5. State two cases where a converged sheaf is best during adjustment. On which gun do you converge?

6. What is the mean height of burst with the following sensings? Two graze and 2 air bursts; 3 graze and 1 air; 4 graze; 3 air and 1 graze; 2 lows and 2 highs.

7. What proportion of grazes do you expect when height of burst is correct for adjustment? For effect?

8. You are 1000 yds. from target, the guns 4000 yds. from it. If you measure the height of burst as 12 mils, what is the actual height? Answer: 3 mils.

9. Why are battery salvos the best means of adjusting height of burst?

10. State two means of changing height of burst.

Eighteenth Hour

1. How do you determine the initial change in height of burst?

2. Your first salvo gives 4 graze bursts 10 mils below target, site 300, range 3000, deflection and D D correct. Your next com-

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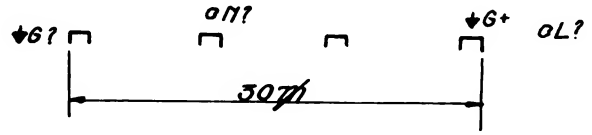
mand is "Site 310, up 5, 3,400." Show by diagram the result of each part of the command.

3. If the first salvo gives 4 air bursts 16 mils high, what is the command to change the height of burst only?

4. Your first salvo with site 310, kr. 25, range 2500, gives the following observations. What is your next command? (3 parts.)



5. If the graze bursts in number 4 had been in air 3 mils above base of T, next command?

6. How many observations are required to justify a 2-mil corrector change?

7. What is an azimuth angle? Name one.

8. Your B C ruler is 6 inches long and subtends 300 mils. How far is it held from the eye?

Nineteenth Hour

1. Name four parts of the tripod.

2. State the use of each of the following: vertical spindle clamping screw, ball-and-socket joint, clamping lever, azimuth clamp, azimuth adjusting worm, azimuth release, azimuth worm.

3. In what direction does our BC telescope read azimuth angles? Why?

4. In applying offsets at BC station, what rule is followed?

5. What three lines determine the obliquity factors for deflection? What angle determines the factor for deflection difference?

6. What uses has the BC telescope? Give five rules for its care.

7. BC station on crest in front of guns. Site to G 240, to T 270. Distance to G 800 yds., to T 2800 yds. By how many yards will projectile clear crest?

Answer: 43.2 yds.

8. The guns are at 7.30 o'clock, angle A 1930, distance to AP 8000 yds., to G 600 yds., to T 2500 yds. Compute data for opening time fire with open sheaf, using site 305.

Answer: Def. 2070, on No. 2 open 10, site 305, kr. 25, BR or BL 3000.

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Twentieth Hour

Pars. 1223–1224, 1321–1344, D. and S. R. F. A.

1. When do you begin fire with a range surely long?
2. What are the two principles of bracketing? Par. 1327.
3. How many sensings are necessary for a range change in adjustment?
4. What kind of burst gives most accurate sensings for a short range? A long range?
5. At medium ranges, how much does a change of 1 mil in site affect your range? Of 1 point of the corrector?
6. Give two examples of each of the following kinds of targets and state the bracket sought for each: stationary target, slowly moving target, transient target, rapidly moving target, instantaneous target.
7. Which limit of a bracket requires the larger number of sensings to establish it definitely?
8. Your first salvo with time fire is lost, what will you do?

Twenty-first Hour

Pars. 1218, 1221, 1270, 1246–1252, D. and S. R. F. A.

1. What is the command for battery salvos? Battery volleys? Platoon salvos? Fire by piece?
2. With wind from right to left, which gun is fired first in adjustment by salvos? On which side of target do you prefer each burst?
3. How may fugitive targets be attacked successfully?
4. Against what kinds of targets are salvos used in adjustment? Volleys?
5. Against what kinds of targets is time fire used for effect? Percussion fire? Are the same kinds of projectiles used in adjustment?
6. When may it be necessary to change from time fire to percussion fire during adjustment?
7. When may the chief of platoon or chief of section conduct the fire of his gun or guns?
8. What command indicates that direct laying is to be used?

Twenty-second Hour

This assignment is a short test on the BC telescope and is written by the battery instructor. It should be short and detailed, but as comprehensive as possible. Candidates may obtain help in answer-

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ing questions, so thought should be required. Some suggested questions follow.

1. How is the tripod best set on sloping ground?

2. Name four parts which are tightened to hold instrument in place when set up.

3. What parts are used in adjusting the following: distance between eyes, clarity of vision, mil scale for observing horizontal position of instrument?

4. What is the best method of focusing?

5. State six rules for the care of instrument.

6. Can the site be determined when instrument is not level? Explain.

7. Show by diagram a method of adjusting the site.

8. How is backlash guarded against? etc.

Twenty-third Hour

Pars. 1354–1393, D. and S. R. F. A.

1. When are ranges effective?

2. At what limit of bracket do you first fire for effect against moving targets? Against other targets?

3. In searching a bracket, what is usually first range change?

4. Under what circumstances does B.C. go into fire for effect with a bracketing salvo? When does he continue adjustment?

5. When do you fire 100 yds. short of short limit of bracket? When may the long limit be included and when should it be included in fire for effect?

6. How many observations are necessary at each limit of a 200 yard bracket?

7. How may you distinguish your projectiles from those of another battery firing on the same target?

8. In going into fire for effect, when is Kr raised 3 points? When 5 points? Is a high or low burst more effective?

9. What per cent. of shots should be on graze during fire for effect? Is this proportion effected by range?

10. How may a front of 12 mils be covered by time fire? 35 mils? greater than 35 mils? Is the right piece directed on the right edge of the target?

11. At mean height of burst, how many yards will each gun cover? May the full traverse of the carriage be used? What is one turn of the handwheel equal to in mils?

12. What two methods are used in sweeping fire? Which is better?

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13. What is the limit of rapidity of fire for effect? Are salvos ever used for effect?

14. What kind of fire is used against infantry in the open? In position in trench? Artillery in position? Infantry in march formation? Infantry deployed advancing by rushes?

15. What bracket is used against rapidly approaching or retreating target?

Twenty-fourth Hour

1. In time fire there is a moment when adjustment must cease. When and why?

2. What is a "bracket" and how do you get it?

3. You have poor effect at the short limit of your "bracket" established with one observation. What range do you include in your fire for effect?

4. What site should be used and how should Kr. be used on a gentle slope without much depth? On a long steep slope?

5. When is "Fire at Will" used? What range for infantry? For cavalry?

6. What is done if adjustment on a target is impracticable?

7. You have 3 graze shorts and a very high over on your first salvo at 3800. Df. and D.D. correct. Give next command.

8. From your B.C. station you make the following measurements: angle A 5700 guns to left front forming angle G-BC-T 190 mils, distance to AP 800 yards, to G 70 yds., to T 2000 yards. What deflection and D. D. is sent to guns for parallel sheaf?

Answer: Df. 5660. On directing piece open 20.

Twenty-fifth Hour

1. When is reciprocal laying used?

2. After announcing the deflection, the executive gives what command if he wishes to form the sheaf by reciprocal laying?

3. What does the chief of section of the directing piece cause his gunner to do?

4. What do the chiefs of the other sections cause their No. 2's to do?

5. What does each chief of section other than the chief of section of the directing piece do as the deflection reading on his rammer staff is called out?

6. The chief of section of the directing piece now causes his rammer staff to be raised for what purpose?

7. Reciprocal laying results in what kind of sheaf?

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8. No. 2 gun is the only piece that can see the A. P. Gunner of No. 2 reads deflection to No. 1 as 1545, No. 3 as 4720, No. 4 as 4745. What deflection is set on these three guns?

9. Hand in a diagram to illustrate method of reciprocal laying. Prove to your own satisfaction by the aid of this diagram that the method authorized in Par. 967 will always lay the guns parallel.

10. Your B.C. station is on a crest 400 yards in front of your No. 2 gun in the line of fire. Angle A is 3840 mils; distance to AP 2400 yards; to T is 3600 yards. Site to guns is 220; site to target 280. You wish to open fire with a sheaf 10 greater than parallel. Wind from the right flank. What firing data is sent to the guns? By how many yards will the crest be cleared?

Answer: Df. 3960. On No. 2 open 5, site 290, kr. 35 (assumed). B. L. 4000. Clears by 17 yards.

Twenty-sixth Hour

Pars. 1398–1412, D. and S. R. F. A.

1. Name the two parts of Fire for Adjustment in Percussion Precision Fire and the range determined by each.

2. The following sensings are made during Trial Fire: 2400, —; 2600 +; 2500 +, — Next command? If the two sensings at 2500 had been —, —, next command?

3. Your trial range is 2550, what is the command for beginning improvement fire?

4. Name seven classes of targets.

5. What kind of projectile is most effective against (a) infantry entrenched, (b) infantry in interior of woods, (c) a staff party, (d) signalman on tower?

6. A salvo fired against approaching hostile cavalry at 4000 is sensed over. Give next command for range. When a bracket has been obtained, how is fire for effect conducted?

7. When is artillery most vulnerable?

8. In open warfare, what front in yards may be effectively attacked by one battery if the target is (a) artillery and shell is used, (b) artillery and time shrapnel is used, (c) infantry?

9. What is the method of ranging used in attacking (a) captive balloons, (b) aeroplanes and dirigibles?

10. Describe kind of projectile, method of fire, and depth of bracket employed against machine guns in the open.

Twenty-seventh Hour

1. The following sensings are obtained during the first series of improvement fire: 2500– – – – – –. Next command? If two of the

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bursts had been over, next command? If two had been doubtful, next command? If two had been over and two doubtful, next command?

2. When is laying on a burst necessary?

3. No. 2 has fired a high burst. No. 1 gunner lays on the burst and notes his azimuth scale reading is 6000. He selects an aiming point and reads its deflection as 3200. What deflection will he use to lay his piece on the point of burst? Answer: 3600.

4. Explain reciprocal laying, using a diagram.

5. The B.C. designates his telescope as an aiming point. His station is on the right flank 200 yards from the guns. Angle A is 2200, range to T 4000 yards. Find deflection and deflection difference for parallel fire. Answer: Df. 2150, DD 0.

6. The guns are about 32 yards below his station, what site is sent to the guns if the site to T from B.C. station is 295?

Answer: 305.

7. 600 yards in front of the guns there is a crest 60 yards high. By how many yards will the mean trajectory clear or fail to clear this crest? Answer: Clears by 11 yards.

8. What is the minimum range at which the guns can fire with this site? Answer: 2950.

9. The target in the above problems is an enemy battery and the wind is from the right rear. Give complete data sent to guns for opening time fire.

Twenty-eighth Hour

Pars. 1413–1417, D. and S. R. F. A.

1. Describe two methods of adjusting fire on enemy entering dead space. (Diagram.)

2. At a range of 3000 yards, how much is the burst range increased by lowering the corrector one point?

Answer: See range tables.

3. On a 60 mil slope, what is the decrease in elevation in 1000 yards? In 100 yards? Express the answer in both yards and mils.

Answer: 60 yards or about 20 mils. 6 yards, or about 2 mils.

4. How would you obtain a uniform height of burst in searching down a 60-mil reverse slope?

5. On a 90-mil slope, what is the decrease in elevation in 100 yards?

6. Show by diagram infantry extended down a counter slope and the effect on the point of burst of one correct change in data sent to the guns in searching this slope.

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7. Is there any limit to the slope which may be reached by percussion fire?

8. What is ricochet? Describe conditions favorable to its effective use.

9. Your target is infantry concealed to a depth of 500 yards on a reverse slope of about 60 mils. You obtain a bracketing salvo on the crest with normal height of burst and correct distribution at 2200 yards. Give commands for searching down and up the slope so as to surely include the infantry, to keep the height of burst effective, and to change the range by not more than 100 yards at each bound.

10. Having obtained an adjusted range of 2525 with No. 1 in percussion precision fire, what is your command to cease firing with this piece? To begin firing with No. 2?

Twenty-ninth Hour

1. The base of a right triangle is 10 yards, the hypothenuse is 13 yards, what is the length of the other leg?

2. What is the use of each of the following parts of the aiming circle? Upper leg clamps, vertical spindle clamping screw, clamping lever, wing nut, azimuth adjusting worm, elevating worm, illuminating window, telescope elbow, objective, centering bubble.

3. What kind of spring takes up backlash in the range finder?

4. State three personal adjustments required on the B.C. Telescope, 1915 Model.

5. Name three parts of the B.C. Telescope for which adjustment is made for backlash.

6. What three measurements must be made on the B.C. Telescope in order to compute all initial firing data?

7. What instrument is used for obtaining ranges in artillery firing? State another general use for this instrument.

Thirtieth Hour

Pars. 990, 1250, 1259, 1266, 1324, 1335, 1339, 1355, 1359–1363, D. and S. R. F. A.

1. What is the theory of the range finder?

2. What three personal adjustments are made on the range finder, and how?

3. What is meant by halving adjustment?

4. Show by a diagram how you would test a range finder for a range adjustment.

5. State one reason why the method of bracketing a target for range is the best method of adjustment for range.

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6. State two conditions which influence the depth of a bracket which should be sought on a target.

7. Name three conditions under which you would consider a range obtained in time fire as approximately correct.

8. You are firing with time fire and obtain a bracketing salvo. State one case in which you would not go into fire effect and one in which you would continue fire for adjustment.

Answer: Pars. 1359, 1290–1294.

9. When may a range 100 yards short of the short limit of a bracket be included in fire for effect?

10. When must the long limit of a bracket be included in fire for effect?

11. You obtain a mixed salvo at a range of 3200, firing on infantry entrenched. At what ranges will you fire for effect if the mixed salvo is over? Short?

12. In fire for registration, how many observations are desired at the short limit of a 100-yard bracket? At the long limit?

Thirty-first Hour

1. State the use of each of the following parts of the range finder: vertical spindle clamping lever, azimuth worm, azimuth release, azimuth adjusting worm, tilting joint, locking lever, elevating knob, trunnions, spring catch and bolt, buffers, range roller, range adjusting scale, knurled roller.

2. Show by diagram the two stake methods of adjusting the angle of site mechanism of the B.C. telescope.

3. State a use of each of the following parts of the B.C. telescope: locking collar, elevating knob, leather covers, tubes, reticule.

4. State a use of each of the following parts of the aiming circle: tripod head bushing, leather dust guard, angle of site vial, telescope elbow, needle release, stand for plane-table work.

5. State two personal adjustments for the B.C. telescope and the range finder, and one for the aiming circle.

6. State five rules for the care of fire-control instruments.

Thirty-second Hour

Pars. 1308–9, 1318, 1338, 1368–9, 1415, D. and S. R. F. A.

1. Define height of burst.

2. Your target is 2 mils wide. What kind of sheaf is used in adjustment?

3. Define: sector, reference point, registration mark.

4. What officer is responsible for replacement of casualties in the firing battery? For replacement of ammunition?

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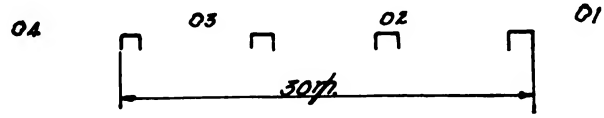
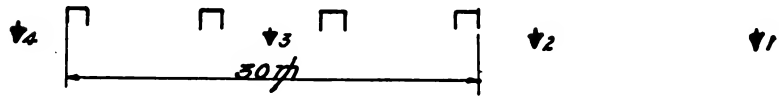
5. Your target is a hostile battery, firing. Your opening salvo with site 300, Kr. 30, BR, A 3000, is observed as indicated. What is your next command?

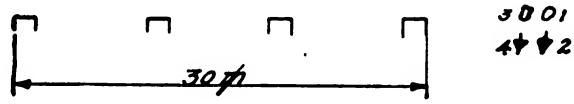


6. If the salvo in question 5 had been as follows, next command?

7. If as follows, next command?



8. If as follows, next command?



9. In percussion precision fire, you make the following sensings:

1st	round,	2400, ——	20 L, ?	Next command?
2d	"	2400, ——	2 L, —	Next command, in full?
3d	"	2800, ——	4 L, +	Next command?
4th	"	2600, ——	3 L, +	Next command, in full?
5th and 6th	"	2500, ——	—, +	Next command, in full?
7th and 8th	"	2500, ——	— ,+	Next command, in full?

Thirty-third Hour

1. Define contour. How can you learn the difference in elevation between gun and target when the location of each is indicated on the map?

2. Your target is hostile infantry assembled in a copse of trees visible from your station. Selecting a tall, dead tree in the rear as an

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A. P., you measure angle A as 3560, site to T as 295 and to G as 295. You estimate distance to T as 1000 yards, to A. P., as 8000 yards, and to G as 2000 yards, guns at about 7 o'clock. Wind is from the right. What data is sent to the guns for the initial salvo?

Answer: A. P.,——, Df. 2760. On No. 2 open 10, site 300, kr. 30, BL 3000 (2800).

3. 4000 yards in front of the target and in the line of fire, there is a crest, to which you measure the site from your station as 345. What is its site from the guns? Answer: Site 314.

4. What is the minimum range at which the crest can be cleared? Answer: 2950 yards.

Thirty-fourth Hour

1. On the gridded section map of Camp Zachary Taylor, Ky., scale 1—10000, the following coördinates are read by the battery commander. Locate the points on the map and compute all data for the initial salvo on the target, assuming it to be a hostile battery whose fire is to be silenced.

AP. 3908040	G. 3907080	T. 3909550
1963565	1964250	1964390

Answer: Deflection 690. On No. 2 open 20, site 300, kr. 30, BR 2400 (2475).

2. Directly in line of fire there is a crest surmounted by a building, at a distance of 520 yards from the guns. The base of the building is on the 535 ft. contour and the building is 16 ft. high. By how many yards will the mean trajectory clear this building?

Answer: By 3 yards.

Thirty-fifth Hour

Pars. 1262–1269, 1271–1274, 1276, 1333, 1354–1357, D. and S. R. F. A.

1. When is a burst sensed as "below over?" (Diagram.)

2. If you are a flank observer, well to the right of the line of fire, on which side of the target will a graze burst appear if it is directly over the target in the line of fire? If directly short?

3. Which indicates more surely a short range, a low short or a graze short? Explain.

4. Firing on a battery target, you obtain the following sensings:

3200 G− L? N? L?
3400 L+ N+ G+ L?
3300 L+ G+ L+ L?

Give commands for the next four volleys.

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5. Firing on infantry entrenched, you sense as follows:
1st salvo, 4000 L+ N+ L? N? Next command?
2d salvo, 3600 G– G+ G+ G+ Next two commands?

6. Firing on cavalry advancing, you sense as follows:
1st salvo, 3600 L– G– G– L– Next command.
2d salvo, 4200 L+ L+ G+ G+ Next command.

Answer: Up 3, B 2, 3400.

7. Your first salvos have given you proper sensings on three guns, but one is lost. How will you find out which is lost while continuing the adjustment?

Thirty-sixth Hour

Pars. 1064–70, 1089–94, 1341, 1358, 1360, 1392, 1404, D. and S. R. F. A.

1. State five requisites of an excellent gun position.
2. State four requisites of a good observing station.
3. On what kind of target may you assume a bracket on range sensings from only one salvo? Without any previous sensings?
4. What change in deflection will be made to compensate for the movement of a target, moving at a walk from right to left? At a walk at an angle of 45 degrees?
5. On a moving target, what range should be first used for effect?
6. State two psychological reasons for announcing sensings in a clear tone.
7. The B.C. measures the height of wheel of No. 2 gun as 5 mils. What is the range to the guns? Answer: 278 yards.
8. Your guns are located 400 yards behind a crest to which the site is 415. The ground beyond the crest is a slope with site 305. What is the minimum range from this position? Answer: 3575 yards.

Thirty-seventh Hour

1. Define magnetic deviation of a compass and state two causes.
2. From your map you read the true north bearings to three points as 480 mils, 1397 mils, and 4726 mils. With a compass you read the magnetic bearings as 563 mils, 1428 mils and 4795 mils, respectively. What is the magnetic deviation of your compass from the true north in this position? Answer: 61 mils W of True N.
3. In what direction is a magnetic bearing read?
4. From your B.C. station you read the magnetic bearing to your target as 6293, to the guns as 4226, and to the aiming point as 2964. What is the angle at A? Answer: 3071.
5. You estimate the distance to T as 2400 yards, to G as 600 yards, and to AP as 5000 yards. What deflection is sent to the guns? Answer: 2740.

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Thirty-eighth Hour

Pars. 833–837, 952–968, D. and S. R. F. A.

1. When is it necessary to lay on burst? To use reciprocal laying?

2. You are the executive and know that the bearing to the target as read on your compass is 6100. You set up your compass in rear of the line of guns and directly behind No. 1, and read the bearings from panoramic sights of guns to compass as 2900, 2500, 2220, and 1940, to numbers 1, 2, 3, and 4 respectively. Using your compass as the aiming point, what deflection is set off on each gun? (Diagram.)

Answer: No. 1, 3200; No. 2, 2800; No. 3, 2520; No. 4, 2240.

3. You have been firing on a target for effect, when it disappears at a range of 3000 yards. Your B.C. station is 500 yards, to the right flank of the line of guns and 40 yards above them. You are now ordered to adjust your fire upon a second target, which measures the same width in mils as the former target, but which you estimate to be 6000 yards away. The site from your station to the new target is the same as from your station to the old. Site from guns to old T is 300. Give complete commands for shifting your sheaf, if you measure the second target as 200 mils to the right of the first. (Diagram.)

Answer: Rt. 80, On No. 4 open 10, Site 295, Down 5, Br. 6000.

Thirty-ninth Hour

Pars. 1007, 1372–1381, D. and S. R. F. A.

1. In percussion precision fire you sense as follows during Trial Fire:

4th Command,	2600, +, -	Next command?
5th "	2600, -, +	Next command?
6th "	2600, - - + - - - + -	

What is your adjusted range to the nearest yard? Adjusted range set on gun? Answer: 2617 yards, 2625 yards.

2. If, in the series of 8 rounds fired in question 1, one of the shorts had been sensed "target," what would be the exact adjusted range? Range set off? Answer: 2612½, (b) 2600 or 2625 yards.

3. Having adjusted the four guns at ranges 2450, 2425, 2450, and 2475, give command for opening fire for effect.

4. With axial observation, when do you stop making deflection changes after each round in trial fire?

5. Your target is enemy infantry concealed in a strip of woods 60 mils wide. Your first salvo is sensed G - L + N + G -, with the right gun on the right edge of the target and your sheaf about

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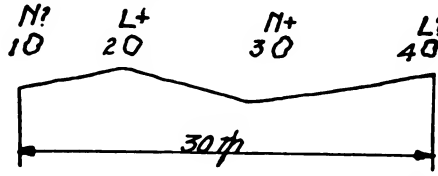
15 mils wide, range 3000. What commands will you give for opening volley fire sweeping?

Answer: On No. 1 open 10, Up 3, Battery 4 rounds sweeping by 5 mils or 3 rounds sweeping (no horizontal scale), 3000.

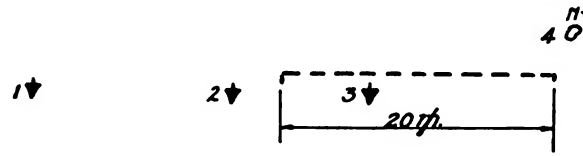
Fortieth Hour

1. Firing on an enemy trench with time fire, Si. 300, Kr. 25, Br. 3200, you observe the following bursts. What is your next command?



Answer: Right 10. On No. 2 open 20, Down 5, 2800.

2. Firing with shrapnel on infantry behind a low stone wall, battery left, 3000, you observe the following.



Next two commands:

Answer: On No. 1 close 5, Up 5, Battery 2 rounds, 3000; 3000

3. If your observations at 2800 show D and DD correct, with four grazes 10 mils below target, next command? If grazes were 5 mils below base? If on line with base? If grazes were 3 mils above base and in line with target?

4. From B.C. station you measure angle A as 3720, guns to right rear forming angle G-BC-T as 1760; distance to AP as 4500, to G as 400, to T as 2400; site to G as 280, to T as 285, complete data for parallel fire?

Answer: Def. 3970. On No. 2 close 5, Si. 290, Kr. 30, Br. 2400.

Smoke Bomb Instruction

Smoke bomb practice is a valuable means of training men in conduct of fire and in handling firing data and should be employed in instruction previous to service practice. The cut on p. 297 shows the organization at the targets.

The board used by the officer at the targets is a big slide rule marked off in divisions to correspond with the line of stakes. The center or sliding part contains four rows of holes, a hole for each stake. Four pegs corresponding to the four guns of a battery are kept in these holes. Deflection is represented by sliding the center right or left. Deflection difference is shown by opening or closing with these nails.

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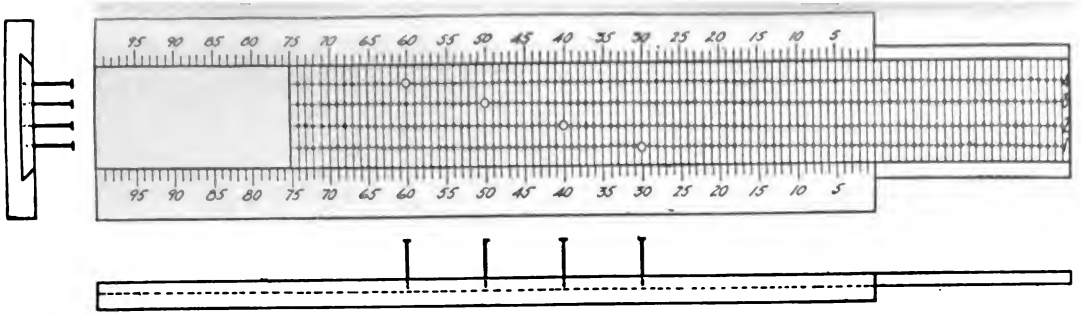
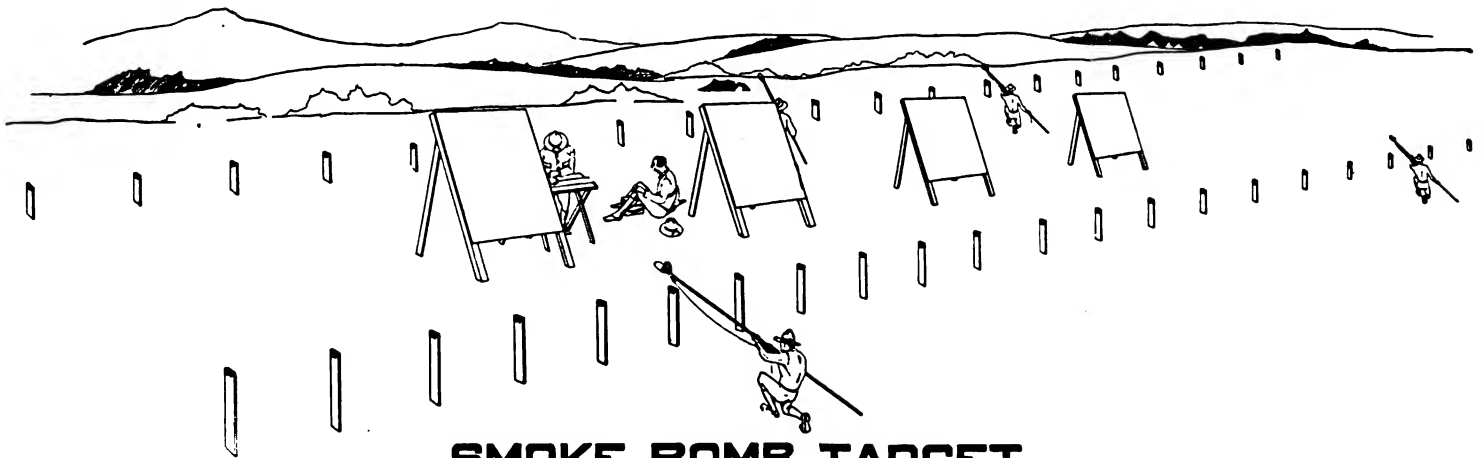


SMOKE BOMB BOARD



SMOKE BOMB TARGET

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CHAPTER VIII

COMMUNICATION

In every army, and in every war since armies and wars first became a part of human activity, the subject of communications has been a subject of first importance. It has often been remarked that an army without a supreme commander, a controlling and directing mind and hand, is no army, but a mob. The leader makes of a mob an army. He plans battles and campaigns and directs the execution of his plans. With the growth of armies to millions of men operating over hundreds of miles of front, the problem of directing and controlling an army becomes increasingly difficult.

Without some simple, rapid, and efficient means at his disposal of transmitting his plans and orders to his subordinate leaders, the supreme commander would be powerless to direct a battle or to conduct a campaign. It is conceivable that he might, from time to time, call together his subordinates and personally impart to them the necessary instructions, and that these subordinates might personally pass on the information to their subordinates. Actually, to some extent, this is done. But such a plan of communication, in addition to being slow and altogether impracticable for any large body of troops, makes no provision for the changing fortunes of war. The best laid plans often fail to work in many prime essentials, necessitating hourly and even momentary changes to fit the many and complex situations that arise.

Thus it becomes absolutely necessary that the commander be provided with some means of keeping in constant communication with the units under his command. He must, at every instant, be thoroughly informed of the situation at the front in order that he may intelligently direct the operations of his troops. And likewise he must be able to transmit to these troops frequently, over long distances and under fire, the directions on which their movements depend.

For this department of warfare the French have a name which like many French words is peculiarly comprehensive and which has been adopted into our own service. They call it "liaison."

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Liaison is a term of broad meaning. It implies both the gathering and the transmission of information. And in addition it implies the dissemination of information in such manner as to accomplish the utmost of efficiency in coöperation; coöperation between infantry and artillery; coöperation between cavalry and infantry; coöperation between artillery and aircraft; coöperation between every arm and branch of the service as well as between the various subdivisions and units of each arm and branch. Liaison is the thing that links together the elements of an army and makes of it a powerful, workable machine, rather than a useless jumble of cogs and wheels. Liaison is the connective tissue of the military body.

The complexity of modern warfare has nowhere presented more difficult problems for solution than in this department of liaison. Vast numbers of troops, covering vast distances, operating with bewildering rapidity, must be directed and controlled in the accomplishment of a single mission. The work of millions of men, carried out under conditions which multiply confusions and difficulties, must be controlled, coördinated, and adjusted. Without efficient means of communication, liaison would fail.

The function of military communication is then the transmission of information from the battle front to the headquarters of the higher commanders in the rear; the transmission of the orders from these headquarters to the units on the firing line; and intercommunication between and within units.

Thus it has become necessary to tax the ingenuity of experts in communication to provide ways and means for the accomplishment and maintenance of liaison. Countless devices have been invented and tried and a large number of different systems are in use in all armies. But, in spite of the best efforts of all armies, there are times when many, or even all, of these systems and methods fail; communications break down, and disastrous results follow.

It is necessary, therefore, that dependence be placed not in any one, but in several good systems, thus minimizing the danger of having communications severed entirely. If the telephone fails, flag signalers should be ready instantly to take up the work; if the flags fail, runners should be dispatched; if the runners are killed, pigeons may be able to get through. Whatever the situation and whatever the difficulties to be overcome, it must be constantly borne in mind that communication must be maintained.

Mechanical difficulties are not the only ones met with in that scheme of military communications which looks to a complete coördination of effort in all branches and departments. Modern warfare is a highly specialized profession. The artilleryman, the in-

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fantryman, the machine gunner, the cavalryman, the engineer, all have their special tasks and methods and problems. And it frequently happens that two or more of these branches, operating together for the accomplishment of a common mission, fail in completely coördinating their efforts because the commander of one fails to properly appreciate the problems and difficulties and limitations of the other. The infantry commander, for example, ignorant of the possibilities and impossibilities of artillery fire, may call upon his supporting guns for a wholly unfeasible task. The artillery commander, unfamiliar with the problems of the infantryman, may expect impossible things of him.

And so we find introduced into our communication plan a coordinating agent known as the Liaison Officer. The liaison officer is the personal representative of his branch or unit of the service with any other branch or unit with which it may be working. The artillery liaison officer, for example, is sent forward to the infantry commander in the front line trenches. There, in company with the infantry commander, he studies the situations and problems which arise, gives the infantryman the benefit of his advice as an artillery expert, and profits by the advice of the infantryman to gather information for his own artillery commander.

Liaison officers are assigned according to a carefully worked out plan, the system being designed with a view to linking up in a complete series every smallest unit in the line to the highest headquarters in the rear. The system, roughly, is about as follows. Military attachés from each of the Allied powers are assigned as liaison officers to the general headquarters in France. Staff officers are detailed from the general headquarters as liaison officers and are assigned to the several armies. These officers travel at night from headquarters to the army to which they are assigned, remain with the army through the day, and return the following night to headquarters. Similarly, liaison officers are detailed from the several army headquarters to the different corps; from the corps to the divisions; and from the divisions to the brigades.

For the smaller units the detail of liaison officers is fixed by regulations and the officers are regularly trained in their duties. Thus, in an infantry regiment, the regiment furnishes a mounted officer for brigade headquarters; each battalion sends an officer or non-commissioned officer to the colonel; and each company sends a non-commissioned officer or soldier to the battalion commander. In an artillery regiment an officer is sent to the division commander; each battalion sends an officer to the regimental commander, and each battery sends an agent to the battalion commander.

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The requirements of a good system of communication are four: reliability, speed, simplicity, and ability to meet without confusion any necessary changes required by the tactical situation.

Reliability is necessary because plans are made and operation orders formulated on the assumption that communication is to be maintained and is available at all times; speed, because at periods when necessity for communication is vital, time is usually an essential element; simplicity, as an essential to rapid operation, maintenance, and repair by inexperienced personnel; ability to meet tactical changes, to insure flexibility and adaptability to meet unexpected dispositions of the enemy.

It is not always possible to embrace all these requisites in any one system but attempt should be made to combine as many of them as practicable. Experience has shown that the establishment of a system of main centers of communication, connected to each other by numerous and varied means of transmitting information, is the only method which can approximately fulfill the above conditions. In addition to these main centers, subsidiary centers for brigades and regiments are established. These subsidiary centers are the centrals for intercommunication in their respective units and are joined to the main centers by the shortest and safest routes.

Artillery Units

In each artillery brigade, and regiment, there is a detachment of officers and men, for signaling duties. In each unit, one officer is detailed as radio officer and one as telephone officer. The soldiers are radio, wire, or visual signalers, as required.

The artillery signal details install, maintain, and operate all radio, wire, and visual stations from and including artillery regimental headquarters, forward. The Signal Corps assigns all long-wire circuits from its network necessary for the artillery and operates the large permanent switchboards of the artillery centrals.

Means of Transmitting Information

The means of transmitting information in the field include electrical systems, visual systems, and message-carrying agencies.

Visual Signals

These signals include projector, helio, flag, and fireworks.

Projectors:

The projector is the most efficient and important of all the means of visual signaling. Messages are sent by international code of dots

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and dashes. The speed limit is about twenty characters per minute. Due to efficiency of projector signaling systems, it was an habitual rule to parallel all wire lines near the front with the lamp lines for use in emergency.

Heliograph:

The heliograph was unused in trench warfare, as it was superseded by the projector.

Flag:

The flag was little used in trench warfare. In open warfare, both wig-wag and semaphore will probably be used to a considerable extent.

Panels:

These are all used for a single purpose: communication with aeroplanes from the ground. There are four kinds of panels: identification, rectangular, marking, and signal shutter panels. The first three types are made of white muslin of varying sizes. Various arrangements of identification panels with rectangular panels allow certain most used and most important conventional signals to be made. The shutter panel is made of both black and white cloth and by means of a string alternately discloses a black or white surface allowing dots and dashes to be made.

Rockets, Bombs, Very Pistols:

These are used to make standard emergency conventional signals and any pre-arranged signals which may be directed in the special order for the operation. Signals are distinguished by number of stars, color of stars, kind of smoke, etc. They are of limited use.

Electrical Systems

The electrical signal system, as in commercial life, is the most important and efficient. It includes wire systems (telegraph and telephone) and wireless systems (radio and earth telegraphy, called T. P. S.).

Telephone:

The telephone is probably the best and most used signaling instrument in the world. An efficient telephone system is the governing factor in military communications. In the French army the telephone was used from the seat of government to the headquarters of each company in the close support line trenches.

In the British service, the telephone was replaced by the Fullerphone as far as one mile behind the front line to avoid the overhear-

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ing of conversations by the enemy. In our service the same rule was adopted and the buzzerphone (American adaptation of the Fullerphone) was used near the enemy's lines. For similar reasons all trench lines must be metallic circuits within 3000 yards of the enemy's line, and either twin or twisted cable, well insulated and protected against leaks to earth.

Telegraph:

The telegraph (key and sounder) was used in the French army forward as far as division headquarters. In the British army it was used up to the brigade (our regiment), and we used it to brigade and even regimental headquarters. It is most quick and accurate for the transmission of orders and messages but for its operation, a very highly trained personnel is necessary.

Radio:

Two forms of wireless telegraphy are used in addition to the earth telegraphy, or T. P. S. These forms are the spark set (spark transmission) and the continuous set wave. The spark set is the most portable radio set used. The sending apparatus is carried by three men and the receiving apparatus by two men. If the set is combined for both sending and receiving, it can be carried by four men. The range of the set is up to 20 kilometers, depending on the size of aerial used.

The continuous wave sets in our service are mounted on motor cars. Of these cars, one carries the composite set, while the other carries the charging plant and operating personnel. Five men, including the two drivers, are sufficient to move and operate the set.

Message-Carrying Agencies

These consist of runners, dispatch riders or messengers, pigeons, message-carrying projectiles, and dogs.

Runners:

These are men especially trained to carry messages. They do not run, they walk. They are used in emergency when other means of signaling fail, and to relieve other methods of communication when long messages, orders, or reports are to be transmitted. Runners are distinguished by red arm bands, 1½ inches wide, around the left forearm, and as a rule carry only written messages. Runner routes are always established in anticipation of use and the personnel instructed as to details of the same. If the distance between runner posts exceeds 600 yards, a relay post is usually established.

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Dispatch Riders and Messengers:

These are used to relieve the signal service when roads permit and when the length of matter to be transmitted makes this method desirable.

Pigeons:

Pigeons are used as emergency message-carrying agents from infantry front line units, artillery observation posts, tanks, or aeroplanes. Two birds are sent, each with one copy of the message, leaving one copy to be retained. If birds are scarce and one bird only is used, inclose a copy of the message on the next bird sent out. Each bird can carry two messages, one on each leg. Pigeons are oblivious to shell fire and can fly through gas, but are uncertain at night or in a fog.

Message-Carrying Rockets and Projectiles:

The former are used by front line commanders to the rear, especially in combat, when other means fail. Message-carrying projectiles are still in experimental stage.

Dogs:

Dogs, until recently, were extensively used as message bearers. Their use has now been abandoned as they have been found to be worthless for their purpose under shell fire.

Visual Signaling

Visual signaling, while little used in trench warfare, will undoubtedly continue to be used to a great extent in open warfare. It can be quickly established and is dependent upon no mechanical device liable to fail when most needed. Flags and heliograph may be used by day, with lamps and fireworks at night. It fulfills two necessities, being available during rapid movements when other methods have been left behind and when other systems have been disrupted or destroyed. It is often used to parallel other methods for use in case of their isolation or failure. It is impossible, however, to communicate at great distances without having many stations which may become invisible because of dark or stormy weather. Moreover, it may be impossible to establish a station where the enemy cannot intercept the message or prevent its acknowledgment. Especially is this true in communicating from rear to front. Nevertheless, as there are times when visual signaling is the only available method, every artillery officer should be able to send and receive by semaphore and wig-wag.

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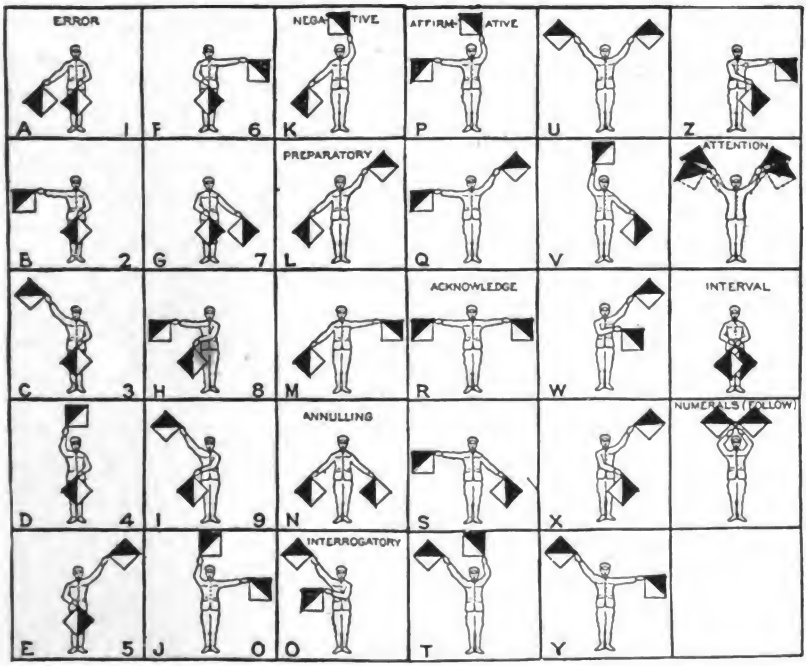
Semaphore

For semaphore two flags are used with a special code, letters being formed by the relative positions of the two flags revolved around a central point like the hands of a clock.



Abbreviations

Letter codes used by field artillery:

A—Error.
AD—Additional.
AKT—Draw ammunition from combat train.
AL—Draw ammunition from limbers.
AM—Ammunition going forward.
AMC—At my command.
AP—Aiming point.
B (numerals)—Battery (so many) rounds.
BS (numerals)—(Such.) Battalion station.
BL—Battery from the left.
BR—Battery from the right.
CCC—Charge (mandatory at all times). Am about to charge if not instructed to contrary.
CF—Cease firing.
CS—Close station.
CT—Change target.
D—Down.
DF—Deflection.
DT—Double time. Rush. Hurry.
F—Commence firing.
FCL (numerals)—On 1st piece close by (so much).
FL—Artillery fire is causing us losses.
FOP (numerals)—On 1st piece open by (so much).
G—Move forward. Preparing to move forward.
HHH—Halt. Action suspended.

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IX—Execute. Go ahead. Transmit.
JI—Report firing data.
K—Negative. No.
KR—Corrector.
L—Preparatory. Attention.
LCL (numerals)—On 4th piece close by (so much).
LOP (numerals)—On 4th piece open by (so much).
LT—Left.
LL—Left from the left.
LR—Left from the right.
LE (numerals)—Less (so much).
MD—Move down.
ML—Move to your left.
MR—Move to your right.
MU—Move up.
MO (numerals)—Move (so much).
N—Annul, cancel.
O—What is the (R. N., etc.)? Interrogatory.
P—Affirmative. Yes.
PS—Percussion. Shrapnel.
QRQ—Send faster.
QRS—Send slower.
QRT—Cease sending.
R—Acknowledgment Received.
RS—Regimental station.
RL—Right from the left.
RR—Right from the right.
RN—Range.
RT—Right.
S—Subtract.
SCL (numerals)—On 2d piece close by (so much).
SOP (numerals)—On 2d piece open by (so much).
SH—Shell.
SI—Site.
SSS—Support needed.
T—Target.
TCL (numerals)—On 3d piece close by (so much).
TOP (numerals)—On 3d piece open by (so much).
U—Up.
Y (letter)—Such battery station

The alphabet should be divided into six groups and so learned:

1	Letters	A B C D E F G
	Numerals	1 2 3 4 5 6 7
2	Letters	H O W Z
	Numeral	8
3	Letters	K L M N
4	Letters	R U N T
5	Letters	I X Y P
	Numeral	9
6	Letters	J Q S V
	Numeral	0

Exact relative positions of the flags are of vital importance in the transmission of a message. These, together with the proper position of the operator, should be sought after from the outset. All characters should be made without bending the arms at the elbow, except those requiring the flag in the vertical position. Characters requiring the use of both arms on the same side of the body should be made by turning the body at the hips. If time is required to understand the signals, it should be taken between characters and not between successive elements of a character or by making the character slowly.

In receiving after the alphabet is learned, the student should not figure out the significance of a character but should recognize it by

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its general form. It must be remembered that facility in receiving is more difficult to attain than facility in sending, so that all practicing may be done with this in mind.

It should be clearly understood that one man is never sent out alone to either transmit or receive a message in the field. Two men are necessary, the one to call each character, the other to write it down or signal it as the case may require.

Never signal with a tangled flag. It is impossible in the field and should not be tolerated during instruction. At any great distance a tangled flag cannot be distinguished. The message must **get through and be understood.** All else is of minor importance except as it affects that fact. For this reason the characters should not be held in position but made sharply and the position of interval or some other character be taken at once. This will force the receiver to recognize the character from his memory of its mental picture. By this method fifty characters a minute should be sent or received.

Wig-Wag

For the wig-wag but one flag is used. Dots are made by moving the flag through a vertical plane to the right of the body, dashes to the left.

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The International Morse or General Service Code is used with all kinds of visual signaling apparatus except semaphore and Ardois, and with the service buzzer and radio instruments.

The International Morse Code

Alphabet

A . —	N — .
B — . . .	O — — —
C — . — .	P . — — .
D — . .	Q — — . —
E .	R . — .
F . . —	S . . .
G — — .	T —
H	U . . —
I . .	V . . . —
J . — — —	W . — —
K — . —	X — . . —
L . — . .	Y — . — —
M — —	Z — — . .

Numerals

1 . — — — —	6 — . . . .
2 . . — — —	7 — — . . .
3 . . . — —	8 — — — . .
4 . . . . —	9 — — — — .
5	0 — — — — —

Punctuation

Period	. . . . .
Comma	. — . — . —
Interrogation	. . — — . .
Hyphen or dash	— . . . —
Parentheses (before and after the words)	— . — — . —
Quotation mark (beginning and ending)	. — . . — .
Exclamation	— — . . — —
Apostrophe	. — — — — .
Semicolon	— . — . — .
Colon	— — — . .
Bar indicating fraction	— . . —
Underline (before and after the word or words it is wished to underline)	. . — — . —
Double dash (between preamble and address, between address and body of message, between body of message and signature, and immediately before a fraction)	— . . . —
Cross	. — . — .

In the wig-wag the positions of the flag should be governed by an easy flexible motion of the wrists and arms, using the arms from the shoulders down. The staff should be grasped by the right hand with the lower edge of the palm about three inches from the end of the staff, the left hand above the right and separated from it by about six inches. In making the characters the entire staff should be pivoted around the center of that portion of itself between the two hands and **not** around either hand. This pivotal portion of the staff should be held opposite a point about midway between the center of the chest and the waist.

To prevent the tangling of the flag around the staff a small loop should be described at the completion of each downward stroke so that in going from one side to the other, as in the letter "a," a figure 8 is made. The loops of this figure should not be too much exaggerated but made just large enough to avoid catching the flag on the staff at the beginning of the upward stroke. In windy weather the loops will have to be made somewhat larger than during calmer periods, their size always being restricted to as narrow limits as practicable. Too large loops have the effect from a distance of foreshortening the appearance of the length of the staff thus rendering the characters vague. In making successive dots or dashes the same

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principle must be observed and additional precautions taken to avoid passing the vertical on the upward stroke, a very common fault of the beginner. All downward strokes should pass the horizontal. The staff should not be held in excess of twenty degrees from the vertical position; forty-five degrees, or even more is another common fault of the beginner.

By this method twenty-five characters a minute should be sent or received.

The Projector

Projector is a military term applied to searchlights used in signaling. The projector is a common searchlight operated by a portable battery and resembling in general form the headlight of an automobile. The portable sets are provided with carriers attached to an equipment that permits of their being carried by one man. They are commonly described by the size in centimeters or inches of the diameter of their mirrors. The portable sets are in three sizes ranging from 5½″ to 14″. Projectors larger than 14″ are used in permanent installations. In trench warfare they were used principally to duplicate important telephone lines and to provide communication between the infantry, planes, and artillery.

The location of both the sending and receiving stations is a matter that calls for careful consideration of several factors. Concealment from hostile observation is of great importance; otherwise messages will either be intercepted or the station put out of commission in a very short time. A good background must be had as projectors are used during daylight as well as during hours of darkness. The lamps should be so located as not to be exposed to the direct rays of the sun, as their reflection would either confuse the message or disclose the location of the station. The receiving station should be so located that it can flash its acknowledgment of messages received without detection by any but the proper station. Also the apparatus should be protected from the weather as far as practicable. Concealment and protection are generally effected by the establishment of stations in dugouts, and improvised shelters of various sorts when nothing more secure is available. Of course, all such stations are well camouflaged. Even the beam may be concealed from the improper observation by projecting it for the first six to ten feet of its length through a wooden chute tapering down to the opening at the outer end, the whole accurately aligned on the receiving station. If the distance over which messages are to be sent is not too great a more nearly perfect concealment may be gained by projecting the

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center of the beam only through a 1½" pipe which has been sighted on the receiving station. As the receiving station must send its acknowledgment from rear to front it is more difficult of concealment. In addition to the above precautions the signaling done from rear to front is usually limited to a dot sent after each word that has been properly received and the signal of interrogation calling for repetition of the last word sent. As the messages sent by projectors are restricted to those between the commanders of the various stations no address or signature is required.

When operating the lamp the first consideration is the proper focusing of the beam. The mirror is parabolic in form and if the lamp is not exactly at the focal point the rays will be too greatly diffused to be clearly visible at any but short distances. This focusing should be tested by projecting the beam on some plane surface at right angles to its axis at a distance of about twenty yards. Adjust the lamp until all the light is concentrated in as small and clear-cut a circle as possible. Next, the light must be adjusted on the receiving station. This is done by means of a sighting tube, a short length of metal pipe fastened to the lamp. When the sighting tube is out of adjustment with the beam, adjustment must be made by changing the reflector.

Messages are sent by the operation of a common telegraph key using the continental code. Great care must be exercised in making the dots and dashes. The filament of the lamp does not reach the highest point of its incandescence the instant the key is closed and so if a dot be made too short the only result will be a dull glow which will be missed by the receiving station. Speed in sending messages by means of the projector is impossible, twenty characters a minute being about the maximum. The dot should be of about ½ second's duration, a dash of about two seconds' duration, the interval between a dot and a dash about the same as the dot, the interval between letters about the same as the dash, and the interval between words of about twice the length of a dash or four seconds' duration. It must constantly be borne in mind that the accurate transmission of the messages is the paramount consideration and excessive speed in sending will only result in confusion and a great waste of time.

In adjusting on the receiving station it is not always possible to do this solely by means of the sighting tube. If the receiving station believes the adjustment to be poor, it will send a series of rapid dots increasing the cadence as the adjustment comes poorer and decreasing the cadence as the adjustment improves until a satisfactory adjustment is finally signified by a steady flash.

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Heliograph

The heliograph is an arrangement of mirrors with a shutter by which the rays of the sun are reflected in dots and dashes. Because of the necessity of ideal weather conditions, fleeting clouds interrupting a message, and the inability to use it at night, the projector has practically superseded the heliograph.

Fireworks

The use of fireworks in modern battles for sending signals has been greatly developed and has been one of the most important means relied upon to send a few fundamental signals from the front line of the infantry to the supporting artillery within the division and between the ground and the airplane.

As the signals that are made by fireworks are always of the most important character, it is essential that the system for their use should be so perfectly worked out that there will be no chance for confusion. The smaller the number of signals to be sent by fireworks, the less chance there is for confusion. The watchword of the firework code must be simplicity.

Experience has shown that it is objectionable to arrange a permanent code of signals. It therefore devolves upon each army to regulate the use of fireworks and to alter at the right time the arrangements made.

In order to avoid mistakes and abuse in the use of signaling fireworks it is absolutely necessary to take the following precautions:

1. Select lights which are easily distinguished from one another; have their meaning based more on their shape than on their color; reserve the most characteristic and visible ones for the most important signals.

2. Codes should be published a fairly long time ahead to all units arriving at the army, and likewise to the units concerned of the neighboring armies.

3. State for each sector, according to the situation, who is the commanding authority (battalion commander, captain, platoon leader) who has the right to use signals; otherwise there is the risk of alarms being given without reason and involving waste of ammunition.

4. Provide relays for repeating the signals when local conditions (lay of terrain; distance, etc.) make it necessary, and ascertain that artillery units concerned have located these relays and know to which advance unit each of them corresponds.

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5. Carefully organize the service of artillery lookouts.

All fireworks classed as signal fireworks are visible, in different degrees, by day and night, with the exception of yellow smoke and flag signals, which are visible in day only.

The fireworks used by the American army are divided into the following classes:

1. **Very pistol cartridges.**
2. **V. B., cartridges (commonly called "tromblons").**
3. **Rockets.**
4. **Flares.**

Establishment and Coördination of Visual Signaling Stations

The selection of a location for visual signaling stations requires the exercise of considerable judgment and a knowledge of certain requirements that are scarcely twice alike.

Such a station must be in close enough proximity to the headquarters with which it is connected or have a rapid and perfect system of communication with the same to permit immediate delivery or transmission of all messages. Good locations are in heavy timber, with well-concealed observatories and a well-hidden sending station, in angles that cannot be seen from the hostile lines, or on reverse slopes.

The station must be plainly visible to all other stations with which it may have to communicate. All signals displayed should be so located as to be invisible to the enemy. In many cases it will be both extremely unwise and impractical to send from rear to front.

Then the location of the forward station must guarantee by every precaution of location, and every other precaution possible, that the receiving station will receive all messages sent if a receiver be on duty, as it may be impossible to acknowledge even the receipt of a message.

There is also the question of the coördination of the various visual signal stations. No signal station, visual or otherwise is ever sufficient in itself. There is always at least one other station with which it must communicate, and generally there are several.

The numerous requirements of the signal station itself generally preclude any possibility of headquarters being as near at hand as could be desired, so the question of liaison between the signal station and headquarters becomes one on which rests the entire purpose of the establishment of the station. Many messages will come through which are for the general information of all headquarters or are not meant for your particular headquarters; in either case they must be

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relayed on to some other station. Occasionally a message will come through from some station farther forward that has lost or can not call its receiving station and has information that must get to the rear without delay. There are many probabilities that will require an absolute certainty of communication between several signal stations.

The two requirements of "location and coördination" of visual signal stations loom larger as their full meanings are more clearly understood. On either one may depend every purpose for which the stations exist. A hasty or superficial examination of the terrain while often necessary for temporary purposes is never finally sufficient. Constant changes, becoming smaller as the stations are improved, will be found necessary. It is never enough just to get the messages through. The question is "Am I in the best location to get my messages through **in an emergency,** under conditions that have disabled all other means of communication? Am I coördinated sufficiently well with other stations so that I could relay my messages through if my Central should go out of commission? In other words shall I be able to continue business as usual while the enemy is doing his worst."

The question of the coördination of the various stations in a visual signal net generally will be settled by headquarters in the form of an order, or existing systems will be taken over as they stand. But improvements are always possible and must be sought always. The very nature of a visual signal station makes it difficult to conceal. It is something that exists for no other purpose than to be seen, yet it must not be seen by the wrong observers. They can and are concealed every day on the front. But constant precautions against aerial and other observation are necessary.

Sometimes a visual signal station cannot be concealed sufficiently; then it must be removed some distance from its headquarters so the shelling of the area in which the station is established will not interfere with the workings of headquarters.

No set of rules that will fit all problems of location and coördination can be devised. It is a matter for clear judgment and a knowledge of the requirements of the reception and transmission of messages, first, and concealment second. Although the two requirements are so dependent on each other they are difficult to separate. Without concealment the station would soon cease to exist or all messages would be intercepted and read and if absolutely concealed it might be too difficult for the station to function properly. Altogether the question is an important one and not one for hasty judgment.

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Signaling by electrical devices is the most widely used, most rapid, and best method of communication. Without it armies could not have grown to their present size as liaison could not be maintained between the various units. In the past this method has been subject to much criticism because of its failure at crucial times. Often this has been due to ignorance of the principles governing electricity.

To the average man electricity is shrouded in mystery. It is not at all mysterious. If the subject is approached from the proper angle, the reason for the various phenomena explained and the relation of one part of a circuit to another gone into, it will at once be apparent to the student that electricity follows a set of well-defined laws, that an experiment completed to-day may be repeated fifty years from now with an exact duplication of results.

Elementary Electricity and Magnetism

We do not know precisely what magnetism is. But we do know how to produce and control it. Magnetism and electricity are not the same things by any means. They are closely related as a study of the following pages will prove. The importance of a thorough understanding of magnetism can scarcely be overestimated. The principles involved are applied in nearly all electrical apparatus—from the simplest electric bell to the largest electric generator.

The name magnet was first applied by the ancients to brown colored stones, known as magnetic oxide of iron (FE_3O_4) because these, as taken from the earth possessed the peculiar property of attracting small pieces of iron or steel. Later the Chinese discovered that if a piece of the ore were freely suspended by a string it possessed the important property of pointing always in a particular direction, nearly North and South; hence, they gave it the name of "Lodestone" (meaning leadingstone), and used it in this manner to navigate their ships. This was the only practical use magnetism was put to for many centuries. In studying the magnetic attractive force of a piece of lodestone by means of iron filings, it will be found that the attraction for the filings seems to be centered at two points on the stone, while at other points no filings are attracted.

The natural magnet possesses yet a third important property, namely, that of imparting all of its properties to a piece of hard iron or steel when they are rubbed together, without apparently losing any of its original force. This steel (a piece of clock spring or a knitting needle will do) will now attract filings, and when freely suspended will come to rest in a northerly and southerly direction

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and can be used to magnetize another piece of steel. Remember these last three points.

Fig. 1.- Natural Magnet Attracting Iron Filings.

From these tests we can define a MAGNET AS A PIECE OF STEEL, OR OTHER MAGNETIZED SUBSTANCE, WHICH POSSESSES THE PROPERTIES OF ATTRACTING OTHER PIECES OF IRON OR STEEL, OR MAGNETIZABLE BODIES TO IT, AND OF POINTING, WHEN FREELY SUSPENDED, IN A HORIZONTAL POSITION, TOWARD THE NORTH POLE OF THE EARTH.

The ends of a magnet are termed its poles. The end which points toward the North geographical pole is generally called the North pole and the other end the South pole.

The law of magnetism is that LIKE POLES REPEL EACH OTHER BUT UNLIKE POLES ATTRACT EACH OTHER. A simple test may be made to prove this. Suspend a bar magnet in a stirrup, as shown in Fig. 2, ascertain and mark its N. pole and then bring near it the N. seeking pole of another bar magnet held in your hand.

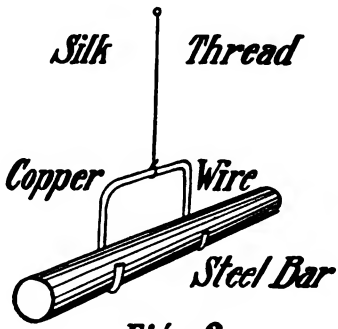

Fig.- 2.

The N. end of the suspended magnet is repelled by the N. end of the magnet held while the S. end of the suspended magnet is attracted by this same N. end.

The above experiments would indicate two kinds of magnetism, or two kinds of magnetic poles, which attract or repel each other,

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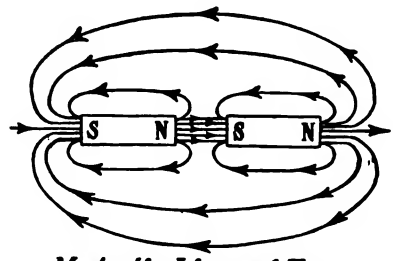
one pole tending to move toward the geographic N. pole, and the other pole toward the geographical S. pole. Since we have called the N. pointing pole the N. pole, and have shown that like poles repel each other, then the magnetism of the earth near the N. geographical pole must be of the opposite kind, or S. magnetism, since unlike poles attract each other.

THE TWO POLES OF A MAGNET ARE INSEPARABLE. If a piece of steel be rubbed with only one pole of a magnet, it will have a North and a South pole. Upon breaking it into two equal pieces, each piece will have a north and a south pole. It is impossible to produce a magnet with only one pole.

The magnetic metals used in practice are STEEL AND IRON. Besides these, the metals nickel, cobalt, chromium, and cerium are attracted by a magnet, but only very feebly. Nickel and cobalt are the best of this class, but are very inferior to iron or steel. For practical purposes all other substances such as copper, lead, gold, platinum, wood, rubber, glass, etc., may be regarded as unmagnetizable or non-magnetic substances. Magnetic attraction or repulsion will, however, take place through these substances.

Magnets may be classified as follows:

- Magnets
  - Natural—The lodestone.
  - Artificial—Steel rubbed with lodestone.
- Artificial Magnets
  - Permanent—Steel bar magnet.
  - Temporary
    - Iron under the influence of a permanent steel magnet.
    - Electro-magnet—Iron magnetized by an electric current.



Magnetic Lines of Force

Fig. 3.

There are three ways of magnetizing a piece of steel. The first method is to bring the piece of steel near a strong magnet, Fig. 3, this is termed MAGNETIZATION BY INDUCTION.

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The second method is by stroking it with another magnet, Fig. 4, known as MAGNETIZATION BY CONTACT.

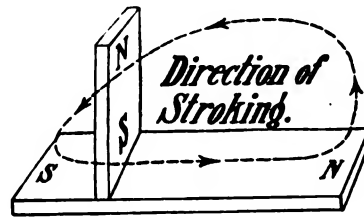

Fig. 4.

The third method is to bring it under the magnetic influence that always surrounds an electric current, Fig. 5, known as ELECTRICAL MAGNETIZATION.

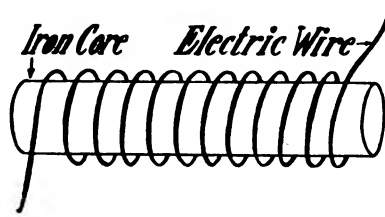

Fig. 5.

The space surrounding a magnet is permeated by MAGNETIC LINES OF FORCE, called the MAGNETIC FIELD OF FORCE, or simply a MAGNETIC FIELD. It is also assumed, Fig. 3, that the magnetic lines of force emanate from the N. pole of a magnet, pass through the surrounding medium, reënter the S. pole and complete the path or circuit from the S. pole to the N. pole through the magnet itself. Every line or curve of magnetic force must have a complete circuit; they DO NOT fly out of each end of the magnet like so much loose hair, hence, as already proven, it is impossible to have a magnet with only one pole. THE MAGNETIC LINES COMPLETE THEIR CIRCUITS INDEPENDENTLY, AND NEVER CUT, CROSS, OR MERGE INTO EACH OTHER. These lines are actually nothing more than stresses set up in the ether surrounding the magnet. The path of magnetic lines, as shown in Fig. 3, is known as the MAGNETIC CIRCUIT. It will now be seen that the magnetic circuit is made up of two parts, the iron of the magnet and the air through which the lines pass. A magnetic circuit is said to be closed when the circuit is composed entirely of magnetic substances, such as iron or steel.

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If we magnetize an annular iron ring, Fig. 6, our magnetic circuit is closed and we have what would be analogous to a closed water pipe with water flowing as indicated by the arrows. Whenever pieces of iron or steel are brought into a magnetic field, the lines pass through them very readily and they become magnetized. If the material is soft iron, when taken out of the field it will lose most of its magnetism, while if it is hard steel, it will retain its magnetism, both substances behaving the same as if they had been in actual contact with the magnet.

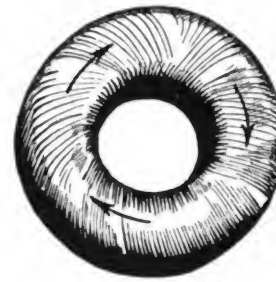

Fig. 6. Iron Doughnut.

Magnetic lines tend to pass along the path offering the least resistance, the same as electric currents. Iron and steel offer the least resistance to the passage of magnetic lines, so are used for magnetic circuits whenever possible. Air offers from one to 10,000 times as much resistance to magnetic lines as iron, depending upon the degree of magnetization. Copper, glass, paper, and other non-magnetic substances offer the same resistance to magnetic lines as air.

Magnetic circuits through substances other than iron are usually made short, so that the number of lines in the magnetic field will be as great as possible. If we bend a bar magnet so that it assumes the shape of a horseshoe, we find that it is a stronger magnet because the magnetic circuit through air is shorter. That air does offer considerable resistance to magnetic lines can be seen from the fact that it is necessary to bring a magnet quite near a piece of iron before any attraction is noticed. THE RESISTANCE WHICH ANY SUBSTANCE OFFERS TO THE PASSAGE OF MAGNETIC LINES IS KNOWN AS RELUCTANCE.

Magnetism can not be insulated. It may be SHIELDED to a certain extent by placing a sheet of iron or steel between it and the object which it is desired not to have affected by the magnetic field. This is somewhat analogous to trying to squirt water through a sponge.

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The theory which seems to best explain the phenomena of Magnetism is known as the "Molecular Theory." It is assumed that the Molecules, which go to make up iron or steel, are each in themselves small permanent magnets. Now the first law of magnetism is that UNLIKE POLES ATTRACT AND LIKE POLES REPEL ONE ANOTHER. (It should be noted in this connection that inasmuch as the North pole of the magnet is attracted toward the North pole of the earth, it is in reality a South magnetic pole.) As these Molecules are ordinarily all mixed up, unlike poles will tend to point towards each other inside the metal and there will be no total outside magnetic effect from the whole piece. Fig. 7 illustrates the position of the Molecules when this condition prevails. The dark portion of the molecules being a North pole and the light portion the South pole.

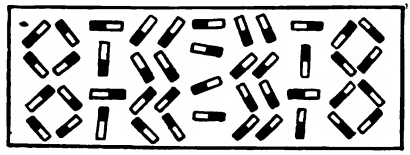

Fig. 7.

Under the influence of magnetism these molecules become oriented so that they all point in one direction magnetically, and their total effect is added, see Fig. 8.

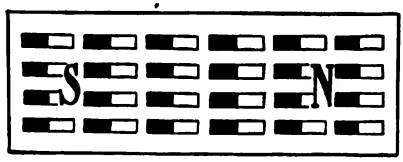

Fig. 8.

It will be seen now that all the North Poles of the molecules are pointing in one direction, and the South Poles in the opposite.

A fact which further supports this theory is that if we take a magnetized bar and cut it up into a number of pieces, each one of the pieces is in itself a magnet with a North and South Pole. We have already learned about a permanent and a temporary magnet. Using our Molecular Theory again to explain why some magnets are temporary and some permanent, the reason is at once obvious. In a piece of soft iron, the molecules are allowed greater freedom and turn much easier than they do in a piece of hard or tempered steel. Now if we magnetize a piece of soft iron, the molecules at once and

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easily assume the position shown in Fig. 8. By the same token then, they quite easily resume their original position, thus satisfying the individual inclination of each one of these molecules.

This is what is known as a temporary magnet, because it quickly and easily loses its magnetism. On the other hand, if we succeed in getting all the molecules in a piece of hard steel pointing in one direction, it is readily seen that the resistance offered to these moving back to their original position is such as to practically obviate this happening. Hence, we now have what is known as a permanent magnet. It should be remembered that a permanent magnet should not be struck a sharp blow, be heated, or in any way have anything done to it which would disturb its molecular balance if all its magnetism is to be retained. If the molecules are agitated in any way, they quite naturally resume their original position at the cessation of such agitation and the magnet suffers in loss of strength.

Experiment No. 1—Apparatus:

Bar Magnet,
Iron Filings,
Wire Nails.

(a) Dip the ends of the bar magnet into the iron filings, and note that the filings cling to the ends of the magnet. The parts to which filings cling are called the poles of the magnet. Those points to which no filings cling are known as neutral points.

(b) Rub a knife blade or other piece of steel with one end of the magnet; always move the magnet in the same direction along the knife. Dip the end of the blade in the filings. Has the blade become magnetized?

(c) Hold one end of the bar magnet against the head of a nail and dip the point of the nail into the iron filings. Note that a magnetic pole has been developed on the point of the nail.

(d) Try the last experiment with a piece of wood or short piece of copper wire in place of a nail, and note that there is no evidence of these substances becoming magnetized.

Magnetic Action.—If a bar magnet be suspended by a fine thread attached to its center, the magnet will turn so that one end will point in a northerly direction and the other in a southerly direction, no matter what the original position of the magnet may be. The end of the magnet that will point toward the north is called the North Pole (marked N.) and the other end is called the South Pole (marked S.). A compass needle is merely a very light bar magnet.

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Experiment No. 2—Apparatus:

Horseshoe Magnet,
Two Bar Magnets.

(a) Suspend a bar magnet by a fine thread attached to its center. When the magnet has come to rest. it will point north and south. Mark the end that points north, to indicate the N. pole. Suspend the second bar magnet in the same way and mark its N. pole. Bring the N. pole of the first bar magnet near the N. pole of the suspended one. Observe that the two poles repel each other. Now bring a N. and S. pole near each other and observe the strong attraction exerted between the two.

(b) Using the suspended bar magnet as in the first part of the experiment, test the poles of the horseshoe magnet, and mark the N. pole.

Laws of Magnetic Attraction and Repulsion.—If the N. pole of one bar magnet is brought near the S. pole of the other, a strong attraction is exerted between the two; but if the two N. or two S. poles are brought together, they repel each other; hence, we can write two laws governing the action of one magnetic pole on another as follows: (1) Like magnetic poles repel each other, and (2) unlike magnetic poles attract each other.

The action of the compass in taking a north and south position can be understood, since investigation has proved that the earth is a gigantic magnet, having one magnetic pole near the earth's north pole, and the other magnetic pole near the earth's south pole.

Experiment No. 3—Apparatus:

Bar Magnet,
Nail,
Piece of Watch or Clock Spring about 3 inches long.

(a) Repeat the third part of Experiment 1, and note that as long as the magnet and nail are in contact the point of the nail will hold a considerable quantity of the filings, but as soon as this contact is broken the nail loses the greater part of its magnetism and most of the filings drop. The nail, being of soft iron, is only a temporary magnet.

(b) Repeat the experiment using the piece of watch spring in place of the nails. Even after the contact between the spring and the magnet has been broken, the spring retains the greater part of its power to pick up the filings. The spring being of hard steel, has become a permanent magnet. Try the bar magnet used in this experiment with a file to see whether or not it is of hard steel.

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Experiment No. 4—Apparatus:

Bar Magnet,
Piece of Watch Spring.

Be sure that the spring used in Experiment 3 is magnetized. After testing the spring by dipping in the filings, cut it into several short pieces, and test each piece for magnetic properties. A magnetic pole will exist at each end of each of the small pieces, and each will have the same power of attraction as the original magnet.

Experiment No. 5—Apparatus:

Horseshoe Magnet,
Bar Magnet,
Iron Filings,
Sheet of smooth, stiff paper.

(a) Lay the bar magnet on the table, and over it place a sheet of paper or piece of glass. Sprinkle iron filings over the paper. Tap the paper gently while sprinkling the filings and note that the arrangement of the filings is similar to the diagram of the magnetic field, shown in Fig. 9.

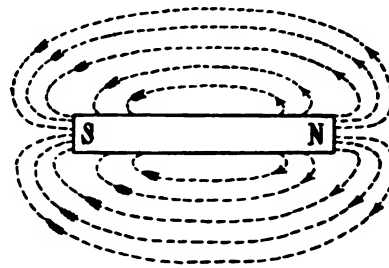

Fig. 9.

(b) Repeat the above experiment using the horseshoe magnet instead of the bar magnet.

Electromagnetism

Electromagnetism, as distinguished from magnetism in a permanent steel magnet, **is the Magnetism Produced around a Conductor when a current flows through it, a conductor being any metal which is used for the purpose of transmitting electricity from one point to another. Any conductor carrying an electric current is surrounded by a magnetic field, exactly the same in nature as the field of a magnet.**

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In Fig. 10 is shown two views of a wire and the nature of the field surrounding it. The small dark spot represents the cross section of a wire; the current we will assume is flowing through the page, from front to back, the magnetic lines will then run around the conductor in a clockwise direction, as indicated by the arrow.

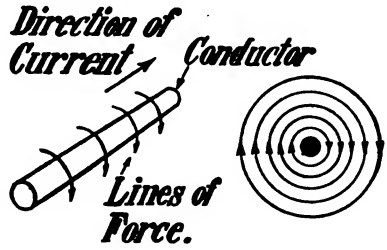

Fig. 10.

Remember they **do not** advance or retreat along the wire, their only motion being around the wire. These lines of force, to use a mechanical analogy, are similar to rubber bands placed around the conductor. Their tendency is always to collapse back upon the conductor, the current flowing through the conductor keeping them distended. This fact is evidenced by the following simple test. Dip the wire in iron filings and note that the filings **do not** stick to the wire. Now connect the ends of the wire to the terminals of a dry cell; place the wire in the filings and observe that the filings stick to the wire, although it is not a magnetic substance. Disconnect

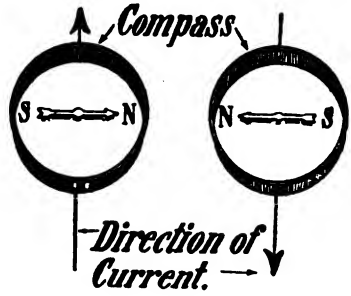

Fig. 11.

one end of the wire and repeat the experiment. It is evident that the magnetic field exists only as long as the current is flowing.

The direction of rotation of these lines of force depend upon the direction in which the current is flowing.

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In Fig. 11 is shown two conductors. The current is flowing in different directions in each of them. The direction of rotation of the lines of force is indicated by the two compasses placed on top of the wire. The North pole of a compass will always point in the direction of the lines of force.

The magnetism resulting from a single straight wire is of little value because it is so weak. However, if the similar effect of a large number of wires is concentrated in a small space, the magnetic effect may be of considerable moment. We will take a piece of wire and

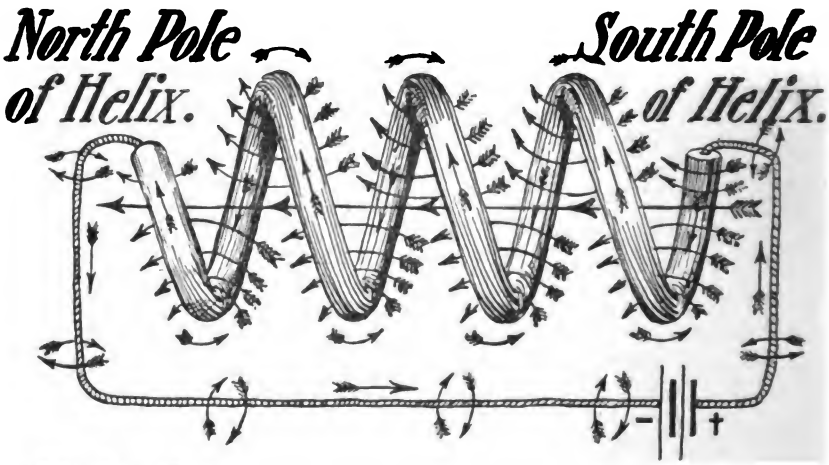

Fig. 12. The Whirls of One Turn Unite With Those of The Next.

wind it so that it resembles a corkscrew and see what happens to our magnetic field. This piece of wire which has been wound into a helix now becomes what is known as a **solenoid**, Fig. 12.

When the wire is made into a coil, as shown, the lines of force cease running around each individual turn and they add up their individual values, thus forming one large field of force, similar to that of a straight bar magnet. This magnetism only exists while a current is flowing through the coil. This concentration of lines of force may be made more pronounced, and the strength of the magnetic field increased by placing a core of iron within the coil, since iron conducts magnetism anywhere from one to 10,000 times more readily than air. There are two names given to this type of magnet, it is called either an "Electromagnet" or a "Solenoid." It is essen-

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tially the same as a straight bar magnet. A North magnetic pole is formed at one end of the core and a South pole at the opposite end. The end at which the North pole is located is dependent upon the direction of current flow. To determine at which end the North pole exists, the right hand rule may be used. Place the thumb of the right hand so that it will indicate the direction of current flow in any individual turn of wire of the coil, and at any position around the turn. The position of the fingers curved around this turn of wire will then indicate the direction of the magnetic lines of force in the core, or will point towards the North pole of the magnet. If a compass is available, the North pole may be easily located by seeing which end of the electromagnet attracts the North pole of the compass.

For most purposes, it is better to construct the magnet so that the force of both the North and South poles may be utilized to act upon a small piece of iron called an **Armature, Vibrator, Interrupter, or Trembler.** The small piece of metal which vibrates in a buzzer is the armature, Fig. 13.

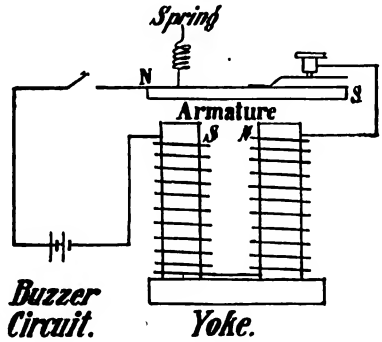

Fig. 13.

This is done by placing an iron yoke across one end of the two cores to form a closed magnetic path from the South pole of one electromagnet around through the yoke to the North pole of the opposite electromagnet. A bar of soft iron placed near the open end of the yoke is strongly affected by both poles, temporarily magnetizing the soft iron armature as indicated. Such an arrangement is essentially the construction used in the telegraph sounder, the ordinary door bell, and many other electromagnetic devices.

Upon closing the circuit (**to have a circuit there must be a metallic connection from one side of a battery through the apparatus to be actuated by the current, back to the opposite side of the**

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battery), shown in Fig. 13, the armature would be drawn over against the poles and held there until the circuit was again broken. In a door bell, then, this would give simply one stroke of the bell. To make the bell ring continuously it is necessary to insert a device for breaking the circuit each time the clapper is thrown against the bell. This is simply done by a spring contact on the armature, through which the current energizing the coils passes. When the circuit is closed, the armature is drawn over toward the poles, opening the circuit at the spring by means of a coil spring, again closing the circuit. This again energizing the coil and draws over the magnet, breaking the circuit, etc., the cycle being completed with great rapidity.

The strength of the magnetic field of any coil depends upon three things:

1st. The number of turns of wire.
2d. The current flowing in the coil.
3d. Material used as a core.

Construction of Electromagnets.—The coils for electromagnets are usually wound in the form of spools. Such a spool may be entirely of fiber so that it can be removed from the core if desirable, or the fiber ends may be forced on the iron core, as shown in Fig. 14.

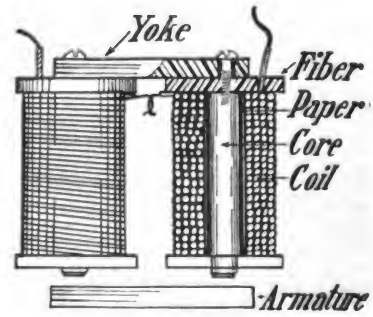

Fig. 14.

In the latter form several layers of paper are wrapped around the core to insulate it thoroughly from the coil. On this spool the insulated wire of the coil is wound in layers. Sometimes the layers are further insulated from each other by a thickness of paper.

Magnet Wire.—The insulated copper wire used in winding coils for electromagnets is known as magnet wire.

Most magnet wire is covered with either silk or cotton. Of the two, silk has the higher insulating properties and is used largely on very fine wire, as a covering of silk is thinner than one of cotton.

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Cotton is used almost exclusively on the larger sizes. Silk or cotton insulated wire has either one or two layers of the insulating materials, and is known as single silk (or cotton) covered. When two layers are used they are wound in opposite directions. As both silk and cotton absorb moisture readily, wire insulated with these materials is sometimes saturated with melted paraffin, shellac, varnish, or some other insulating compound to make it waterproof. More often the coil is so treated after being wound.

Enameled wire is a later development in the insulation of magnet wire. Enameled wire is made by coating the wire with liquid enamel which is then baked on. The advantages of this wire are that it is waterproof, will stand high temperatures, and the covering of insulating material is very thin.

Part of the construction of the Induction coil is the same as the electromagnet. That part of it is called the PRIMARY CIRCUIT. The secondary consists of putting another layer of very fine wire, and many more turns than is in the primary, on top of the primary coil.

We now know that when a current is sent through the winding of an electromagnet, lines of force are established around the coil the same as they are around a plain bar magnet.

We are now going to use these lines of force for a purpose other than attracting pieces of iron.

Faraday, a noted scientist, discovered in 1831, that if a conductor be moved in a magnetic field so as to cut the lines of force, an

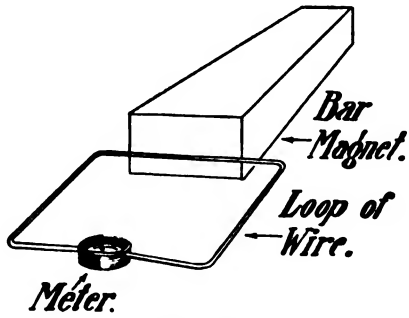

Fig. 15.

electric pressure is generated in the conductor and if the circuit be closed, a current will flow. If we were to take a plain loop of wire and a magnet and swing the loop so that it would run through the lines of force, a current would be induced in the wire, Fig. 15.

If we were to put a galvanometer or some other instrument in

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the circuit, which would indicate when a current was flowing in the loop, as is shown in the above figure, we would find that as the loop passes the end of the magnet, the needle would deflect indicating the presence of a current. It is upon this principle that the Induction Coil and the generator operate.

In the Induction Coil, however, the coils remain stationary, and in the primary coil, the current is turned on and off. This alternately creates and destroys a magnetic field. In all induction coils which we will consider, instead of the windings being placed on a core, which is horseshoe shape, it will be placed on a straight bar. Fig. 16.

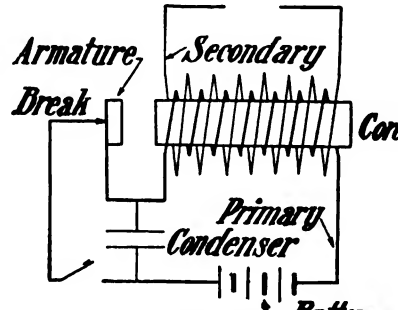

Fig. 16.

If you will examine an induction coil closely, you will see that the core is made up of a number of thin wires bound together in a bundle instead of being one solid piece. This gives us a better path for our lines of force and serves our purpose better, inasmuch as it is more readily magnetized and demagnetized than would be a solid piece of iron. Now when the magnetic field is created in the primary coil, due to a flow of current, the magnetic lines of force, like rubber bands, are stretched out and also pass or cut through the secondary coil, and induce a current within it. This current is very often referred to as an EMF, the initials standing for ELECTRO MOTIVE FORCE. We know that as long as lines of force are cutting a conductor, a current will flow. If the lines of force kept going on continuously, so would our induced current keep going. However, this is not the case in the induction coil. When the circuit to the primary coil is closed, the magnetic field rapidly builds up to a certain maximum and then remains constant. During the time this magnetic field is changing in magnitude, an EMF is generated in the secondary coil with a magnitude which depends on the rate of change of the magnetic field due to the primary coil. Consequently when the field reaches its maximum strength, the rate of change is zero and

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no further current is produced in the secondary coil. But when the circuit to the primary is broken, there is again a change in the number of lines of force passing through the secondary coil, as the magnetic lines of force through the primary decrease from a maximum to zero and another impulse of current is generated in the secondary during this change. The directions of flow of the current generated in the secondary coil during the building up of the magnetic field and during the falling off of the magnetic field are opposite. The large number of turns of wire on the secondary coil, as compared with the number on the primary coil, result in an electromotive force in the secondary coil which may be many times as great as that in the primary coil. By this means it is possible to step up the voltage and make it high enough to jump the high resistance of an air gap (20,000 volts are required to jump a gap of one inch between needle points). If the voltage is stepped up several times, the current in the secondary coil is correspondingly reduced in comparison to that in the primary, since the power output of the secondary can be no greater than the input to the primary, and since the product of the current and voltage is approximately the power. The high voltage obtained by this means is one of the essentials in radio telegraphy and telephony.

In order to secure a practically continuous supply of the high voltage current in the secondary circuit, it is necessary to make and break the circuit through the primary coil very rapidly. To do this, an armature and make and break contact system practically identical to that used in the ordinary door bell, are used. This alternately makes and breaks the current through the primary coil and creates and destroys the magnetic field cutting the secondary coil and thereby induces the high voltage current, flowing first in one direction and then in the other.

Mechanical Generation of Electricity

In the third lesson we learned that when lines of force cut a conductor or conversely, when a conductor cuts lines of force, an electrical pressure is induced in the conductor and if the circuit is closed, a current will flow.

In the induction coil we move the lines of force and the conductor is stationary. In the electrical generator or dynamo, the lines of force are stationary and we move our conductor. The necessary elements of a dynamo for the generation of current are a magnetic field and a conductor or conductors which can be caused to move across the field. The simplest form of such a machine is shown in Fig. 17.

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A loop of wire is mounted on the shaft so that it can be rotated on its axis and cut through the magnetic lines which pass from the North to the South pole of the permanent magnet. At the instant at which the loop is in the vertical position, as shown by the full lines, the conductors are moving parallel to the magnetic lines, and since there are no lines being cut, no pressure is induced. When the

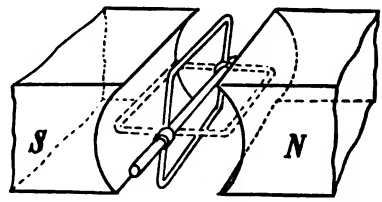

Fig. 17.

loop is in the horizontal position, as shown by the dotted lines, it is moving at right angles to the magnetic lines; and as the rate of cutting magnetic lines is a maximum in this position, the pressure induced will be a maximum.

The direction of the pressure induced, when the conductor is passing through the field in this direction of rotation, is from front to back on the right side of the loop, and from back to front on the left side of the loop. The pressures in the two sides of the loop will tend to cause current to flow in the same direction around the loop and pressure in the loop will be the sum of the pressures induced in the two conductors.

When the loop is moved 90 degrees further it will again be in a vertical position, but the conductor which was at the top in the first case will now be at the bottom, and the other will be at the top. Advancing the loop past this point, a pressure will again be induced in the conductor, but the position of each conductor with respect to the N. and S. poles will be reversed. Since the positions of the conductors have been interchanged and the current has the same direction with respect to the magnetic field and the direction of motion, it will flow through the loop in a direction opposite to that of the first half revolution. That is, the direction of the flow of current through the loop will reverse every 180 degrees.

If two rings be attached to the loop, one being connected to each end, and mounted so they will rotate with the shaft and loop, the pressure at these rings will reverse each time the loop has passed through 180 degrees. Current can be taken from these rings by

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placing a brush on each of the rings, as shown in Fig. 18 and connecting them to a conducting circuit.

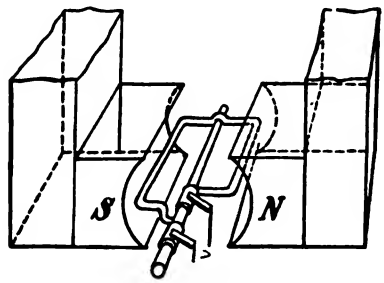

Fig. 18.

Since the direction of the induced pressure changes each 180 degrees, the flow of current in the circuit will reverse correspondingly. That is, an alternating current will flow in the circuit. This changing of current from zero to a maximum value, then decreasing to zero, reversing, building up to a maximum value in the opposite direction, and then decreasing to zero again, is shown by Fig. 19 and is known as a cycle.

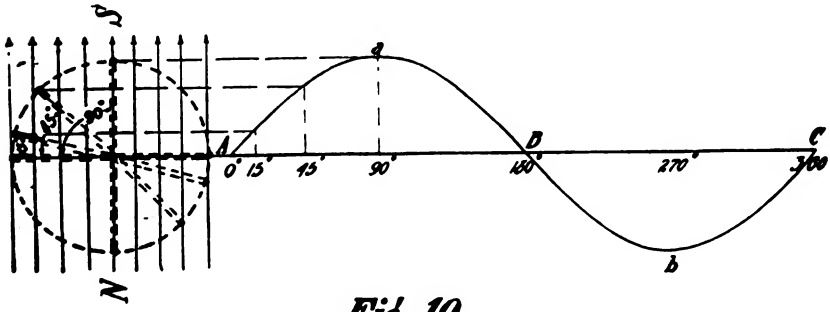

Fig. 19.

The number of cycles per second is called the frequency. When the loop is in the vertical position, as shown by full lines in Fig. 17, the pressure is zero corresponding to point A, or zero degrees, Fig. 19. The curve above the line ABC shows positive voltages, and that below shows negative voltages.

A generator of this type is used in telephone work. Instead of using just one magnet, however, from 2 to 6 magnets will be found in the generators. The shaft and core upon which the wire is wound in the generators is known as the ARMATURE. It is quite obvious that in this generator, the faster the crank is turned the higher will

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be our frequency, and so also will our voltage increase. This is quite obvious as the faster we cut lines of force the more current we will generate.

Chemical Generation of Electricity

I. M. 6-C

We have taken up two methods of generating electricity. First, the induction coil, second, the generator. We are now about to take up the third and the one which we will come in contact with more than the others, which is the chemical cell.

Before going any further, there is one point which should be borne in mind, that is, the nature of the flow of electricity. Before electricity can flow in a circuit, there must be a difference in **Potential.** This difference in potential is analogous to two vessels containing water, connected together by means of a rubber hose. Before water can flow from one to the other, there must be a difference in pressure.

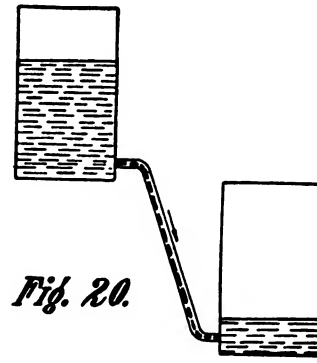

Fig. 20.

As shown in Fig. 20, water is able to flow from the upper vessel to the lower, due to the fact that there is a difference in pressure. This is exactly the case with an ordinary dry cell. The two vessels containing water represent the two terminals of the cell. The hose corresponds to the wire which would be used to connect one binding post with the other. If we were to go a step further and insert a stopcock in the hose so that the water might be turned on or off at will, this would correspond to a switch in our battery circuit. As soon as the circuit is closed, electricity flows from the terminal of high pressure of the cell to the one of low pressure. Electricity flows from positive (+) to negative (—), hence, the positive terminal must be the one of greater pressure. One of the simplest

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ways of bringing about this difference in potential is by means of a chemical cell. Such a cell transforms chemical energy into electrical energy, and is known as a "**Primary Cell.**" There are a large number of possible combinations of metals and chemicals which can be used to make up an ordinary primary cell, some being more effective than others, and each having its respective advantages. In simplest form, the primary cell consists of two different metal plates suspended in an acid solution, called the "Electrolyte." This acid has different effects upon the two plates, Fig. 21.

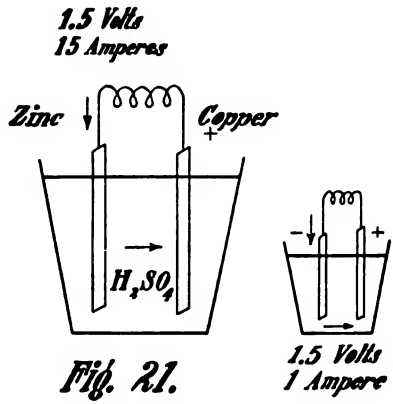

Fig. 21.

For example, with copper and zinc as the two metals suspended in a dilute solution of sulphuric acid, the zinc is much more readily attacked by the acid than the copper. If these plates are connected together by means of a wire outside of the cell, a vigorous chemical action takes place, the zinc dissolving in the acid to form zinc sulphate and liberate hydrogen. The hydrogen liberated carries a negative charge of electricity which travels across the acid to the copper plate, there giving up its charge to the copper plate and passing off as gas. This causes a difference of potential on the two plates so that a current flows in the exterior circuit.

A point to be remembered is that for a cell of this type only a pressure of about 1.5 volts can be obtained regardless of the size of the cell. As is illustrated in Fig. 21, the large cell is 1.5 volts while the little one is exactly the same. The difference is due to the fact that more current may be taken from the large one than from the smaller. The large cell will give current for a longer period than will the small one. This is somewhat analogous to two vessels holding water. If one vessel is larger than the other and they are both full of water, it is obvious that more water can be taken from the larger vessel.

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The metals which may be used as the poles of a cell are listed below according to their relative potential when dipped into a solution acting as an electrolyte. Those near the top of the list are positive to those below. This list is known as the electro-chemical series.

Positive Terminal.—Carbon.
Platinum.
Silver.
Copper.
Lead.
Tin.
Iron.
Zinc—Negative Terminal.

The maximum electric pressure or voltage that can be obtained from any combination of these metals is about three volts, whereas the current capacity is limited only by the size of the cell.

The ordinary dry cell with which you will come in contact, one type of which is shown in Fig. 22, consists essentially of a paste-

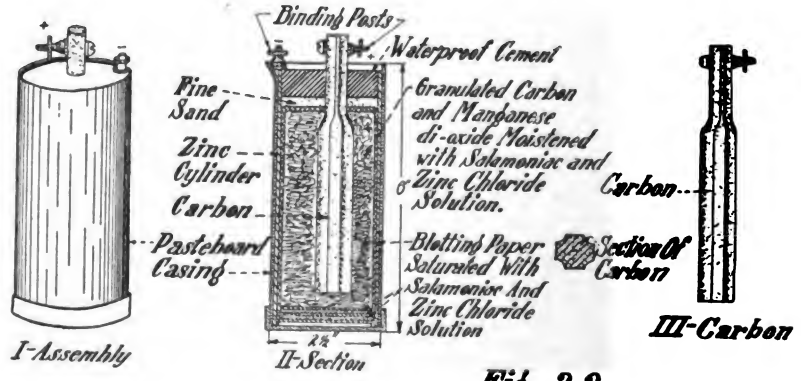

Fig. 22.

board casing, a zinc cylinder, which serves as a container and acts as one plate or pole of the cell, and a central carbon rod, which forms the positive pole.

The zinc cylinder contains granulated carbon and manganese dioxide, moistened with a solution of sal ammoniac and zinc chloride. This mixture acts as the electrolyte.

Everyone has used dry cells and has probably noticed that after a certain amount of work they grow weaker and weaker. What happens inside? The hydrogen gas liberated by the zinc container collects on the surface of the carbon rod. Hydrogen gas has a very high resistance, hence, if permitted to form a film on the

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carbon, the resistance offered to the electricity flowing from the zinc container to the carbon inside the cell is very materially increased. This is **Polarization.** To counteract this accumulation of hydrogen on the carbon rod, a chemical medium called a **Depolarizer** is used. The depolarizer most often used is manganese dioxide as this has an affinity for hydrogen.

The hydrogen that is liberated unites with this substance to form a new chemical compound and is thus prevented from collecting on the carbon. In spite of the depolarizer, however, a battery gradually becomes polarized and its usefulness dissipated. Such a battery may be renewed and further output obtained, in case of emergency, by heating it.

Another type of battery in very common use in signal work is the **"Reserve Cell."** This is essentially the same as a dry cell except that the chemicals are all packed in dry. When it becomes necessary to use the cell, a cork in the top is removed and the cell filled with distilled water. This method of cell construction is quite novel, inasmuch as these cells can be kept indefinitely, provided they have not been filled with water, without deterioration from age.

All of the above-described cells belong to a group known as **"Primary Cells."** We will consider briefly the **"Secondary Cell,"** or **"Storage Cell"** which also finds extensive uses in Signal Corps work. This cell is one which generates electricity by means of chemical reaction, just as in the primary cell. It differs from the primary cell, however, in that when the chemical action has gone on to such a point that the battery is exhausted, it may be restored to its former or charged condition by connecting it to some source of electricity for a period of time. In such a cell the chemical reactions are reversible; that is, the two plates or poles of the cell are made up of such materials as may be chemically changed, due to the passage of an electric current. And then upon using the cell as a source of electricity, this chemical reaction reverses itself to generate the electricity which has been stored through the previous chemical action.

The ordinary primary cell will respond to such a treatment only to a very slight degree. The elements which perform this reversible function most satisfactorily, are either lead plates coated with an active material of lead oxide and lead peroxide inserted in a dilute solution of sulphuric acid, or steel plates containing nickel and nickel hydrate and iron oxide inserted in an electrolyte of potassium hydroxide.

In both primary and secondary cell considerations the "cell" is the individual generating element. Any group of these cells for producing a given power supply is called a "battery."

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Ohm's Law

Before going ahead with further work on electricity and electric circuits, it is necessary to have some understanding as to the relation of the various factors in a circuit to each other. In any circuit through which a current is flowing, we have the three following factors present:

Volts—The pressure or potential difference which causes current to flow.

Ohms—The opposition or resistance ot the circuit which must be overcome before current can flow. It is analogous to friction in mechanics.

Amperes—The current strength, which is maintained in the circuit, as a result of the pressure overcoming the resistance.

A definite and exact relation exists between these three factors, pressure, current strength, and resistance in any circuit, whereby the value of any one factor may be calculated when the values of the other two factors are known. This relation, known as "OHM'S LAW," **Is Very Important,** since it forms the basis for all calculations in electrical engineering. It may be summarized, as follows:

The current strength, or amperes, in any circuit is equal to the pressure, or voltage, applied to the circuit, divided by the resistance of the circuit.

Let E = potential difference, or available pressure, expressed volts, applied to any circuit.

R = Resistance of the circuit expressed in ohms.

I = Current strength, expressed in amperes, to be maintained through the circuit.

Then by the above statement,

$$\text{Current} = \frac{\text{Pressure}}{\text{Resistance}} = \text{or Amperes} = \frac{\text{Volts}}{\text{Ohms}} \text{ or } I = \frac{E}{R}$$

It is now obvious that these units, resistance, current and voltage, were so chosen that a pressure of one volt would force a current of one ampere through a resistance of one ohm. This relation continues, so that it required twice as much voltage to force twice as much current through the same resistance, or that it takes twice as much voltage to force the same amount of current through twice the resistance.

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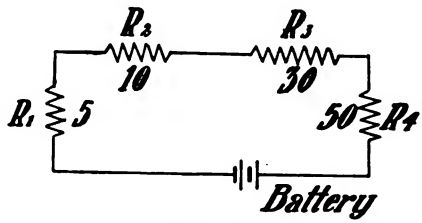
To find any one of the three factors, provided the other two are known, we would use one of the three following formulas:

$$I = \frac{E}{R} \quad \text{or } E = IR \quad \text{or } R = \frac{E}{I}$$

Now it may be necessary in some cases for us to determine what the total resistance of a circuit is before we can calculate for E or I,

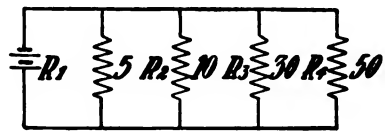


Resistances in Series

Fig. 23.

hence, we must consider an additional formula for finding what the total resistance of a circuit is.

To find the total resistance of a circuit the individual resistances of which are in series is a simple matter, as all we have to do is to add up the individual resistances and the sum thus obtained is the total resistance. Take for example Fig. 23.



Resistances in Parallel

Fig. 24.

the total resistance of this circuit is the sum of the individual resistance, or

$$R = R_1 + R_2 + R_3 + R_4$$

substituting,

$$R = 5 + 10 + 30 + 50 = 95 \text{ ohms.}$$

If our resistances happen to be in parallel (or multiple), finding the total resistance now becomes a little more of a problem. Suppose, for example, our circuit is like the one shown in Fig. 24.

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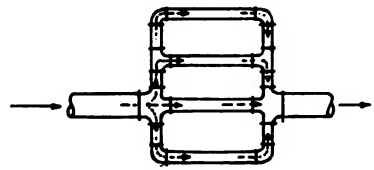
Before going further with this circuit it is well to remember that it is analogous to the flow of water in a series of pipes, as shown in Fig. 25.



Water Pipes
Fig. 25.

It will be readily seen that more water would flow through pipes arranged in this manner than would flow if they were connected in series. It is the same in electrical circuits, resistances in parallel would not offer as much resistance to a flow of current as they would if connected in series, provided of course their individual values were the same in each case. To digress a little further in order to have a better understanding of resistance, it should be pointed out by the instructor that the resistance of a wire depends, not only upon the metal of which it is composed, but also upon its cross-sectional area. The greater the cross-sectional area, the greater will be the conductivity and the less the resistance. A piece of copper wire 1–10 in. in diameter (No. 10 B. & S. gage) 1000 ft. long has a resistance of 1 ohm.

Now to return to Fig. 24, and analyze it, what have we done? By putting our resistances in parallel we are merely adding up their cross-sectional areas, and by doing this we know that the total resistance of the circuit is going to be less than the smallest resistance contained therein. The greater the conductivity the less the resistance. Thus, in Fig. 24, the total resistance may be found from the simple equation:

$$R = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4}}$$

substituting our numerical values, we have

$$R = \frac{1}{\frac{1}{5} + \frac{1}{10} + \frac{1}{30} + \frac{1}{50}} = \frac{1}{\frac{53}{150}} = 2.83 \text{ ohms.}$$

These are the only formulas to which reference will be made and the candidates must know them thoroughly.

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Battery Connections and Practical Use of Ohm's Law

We have found that the voltage of a single cell is very small. This voltage, from either a primary or secondary cell, is generally insufficient to do the work required. Batteries are, therefore, connected up in combinations to deliver the output and voltage desired.

Before going ahead with the various ways of connecting batteries, just a word about the physical connections. Poorly made battery connections is one of the most common sources of trouble in the use of electrical instruments. At the same time it is one of the most easy to avoid and to correct. In making connections, pincers should always be used to tighten down the nuts and the surfaces should always be clean so that there will be a sure and firm contact. It is important that the pasteboard covers on dry cells should not be broken or removed, since if the two zinc containers touch one another, a short circuit will result.

The direction of flow of an electric current may be determined by placing two terminals in a salt solution. The terminal at which the larger amount of gas is given off is the negative terminal, or where the current is flowing toward the cell. The values of current and voltage, which are placed on the several illustrations showing different methods of battery connections, are those which obtain when the batteries used are lead plate storage batteries.

Cells may be connected in four different ways. When it is desired to build up the voltage, the cells are connected in "**Series,**" as shown in Fig. 26.

Batteries in Series.

Fig. 26.

If it is desired to obtain greater current through the exterior circuit, larger cells must be used, or what amounts to the same thing, the like plates of several cells must be connected together so they will act together. This gives the same voltage as one cell but increases the quantity of electricity available. This is called "**Multiple** or **Parallel**" connection, Fig. 27.

When it is desired to increase both voltage and current, it is necessary to make a connection which is a combination of the series

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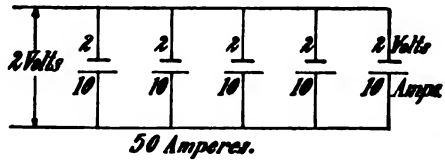
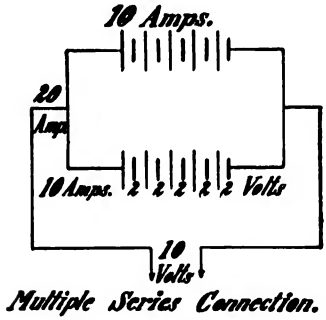
and multiple methods mentioned above, and called the "**Series-Multiple**" and "**Multiple-Series**" connections. Any combination of cells in this method of connection may be made; for instance, the



Batteries in Parallel.

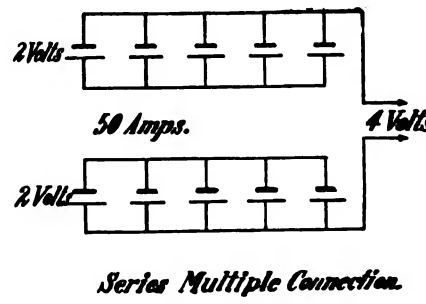
Fig. 27.

cells may be connected, as shown in Fig. 28, so that there will be two groups of five cells, each in series; with the groups connected in parallel, or as shown in Fig. 29, so that there may be two groups of five cells, each in parallel, with the two groups connected in series or any combination between these limits.



Multiple Series Connection.

Fig. 28.



Series Multiple Connection.

Fig. 29.

With our knowledge of resistances of a circuit, the need for connecting batteries in different combinations, as explained above, is more readily understood. For instance, suppose a specific apparatus requires a certain quantity of electricity to make it operate, say, 5 amp. The total resistance of the apparatus and of the wires leading to it, is 10 ohms. In order to supply the 5 amp. then, it will be necessary to supply a voltage of 50 volts, since by Ohm's law, $E = RI$, hence $E = 10 \times 5 = 50$ volts. If the resistance of the exterior circuit connected to a cell is comparatively low, it is necessary to take into consideration the internal resistance of the battery in considering the constants of the circuit. The chemical action of the cells gives a certain amount of voltage. This voltage must force

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the current not only through the outside circuit but through the cell itself, and this latter becomes quite a large factor in the flow of current if the resistance of the exterior circuit is fairly low and a large current is desired. If the resistance of the exterior circuit is very high, the cell resistance may be neglected without material error in the computations.

Suppose that the battery in use in a circuit is made up of two small cells connected in series. Each cell gives a voltage of 1.5 volts normally and has an internal resistance of .3 ohm. The two cells in series give a battery voltage of 3 volts, and resistance of .2 ohm and suppose, further, that it is desired to force 6 amp. through it. If one of the above batteries is connected to the circuit, 3 volts are available for forcing the current through a total resistance of .2 + .6 = .8 ohm. From this, $I = \frac{E}{R} = \frac{3}{.8} = 3.75$ amperes. This is evidently not sufficient. Now place two of these batteries in series, Fig. 30.

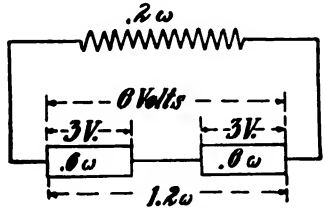

Fig. 30.

This will deliver 6 volts but will also double the internal resistance, making it 1.2 ohms, or a total of 1.4 ohms, including the external resistance. From this, $I = \frac{6}{1.4} = 4.28$ amperes. This is still not the amount desired, and it is seen that while the source of

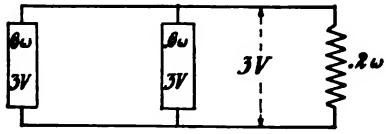

Fig. 31.

E.M.F. has been doubled, the current which this will deliver through the exterior circuit has been increased only a small fraction.

If the two batteries are placed in parallel, Fig. 31, the voltage of only one will be available, 3 volts, but the internal resistance of

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the batteries will be decreased since two paths in parallel are provided or the current to pass through. This would give a total internal battery resistance of .3 ohm, according to the scheme shown above for finding a total resistance of several resistances in parallel, and this gives a total resistance in the circuit of .3 + .2 = .5 ohm. From this, $I = \frac{E}{R} = \frac{3}{.5} = 6$ amp.

A general rule which may be followed in such cases is to connect the batteries in series for use in circuits of high external resistance. With low external resistance, connect the batteries in parallel.

Ohm's law may be applied to any part of a circuit. That is, the voltage between any two points of a circuit is equal to the current flowing between those two points, multiplied by the resistance between those two points. Application of this formula to various portions of a circuit shows where the maximum drop in potential occurs. For example, in an electric light circuit, the resistance of the lamp is far greater than that of the line, so that if 115 volts is supplied by the dynamo, practically all of that potential will be available at the lamp socket. The resistance of the wire to the lamp is very low in comparison to that of the lamp itself. When a large voltage is required for forcing a certain current through it, the power must be correspondingly large. The unit of power, in direct-current circuits, is taken as the product of the voltage and amperage and is called the "watt." One watt of power is being applied when one ampere is flowing at one volt applied E.M.F. This rule may be simply expressed by the equation: W = EI.

For example, a 6-amp. current flowing as the result of a 3-volt potential means a power in-put of 18 watts. In a lamp circuit the current is ½ amp. at 110 volts, this representing 55 watts of power. A storage battery on charge at a pressure of 4 volts and a current rate of 15 amperes is taking 60 watts.

As a watt is rather a small unit, 1000 watts is the usual unit used and this is called a "kilowatt" (kw.). The electrical equivalent of the horse-power unit is 746 watts. One kilowatt is therefore almost exactly 1⅓ hp.

The longer a certain number of watts of power is drawn from a source of supply, the greater the "energy" which is consumed. The unit of time used in this connection is the hour. A watt of power drawn for one hour is called a "watt-hour." It is not difficult to secure rather large currents for a very short time, but a substantial source of supply must be had to maintain a considerable current for a long time. The watt-hour is the unit which expresses this

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requirement. As the watt-hour is a small unit, the usual unit used commercially is the kilowatt-hour (kw.-hr.), 1000 watt-hours.

Theory of the Telephone

Telephony is the art of transmitting articulate speech and other sounds between distant points by means of fluctuations in an electric current flowing between those points. The successive vibrations of the human voice that form distinguishable and intelligible sounds constitute articulate speech. These vibrations are probably the most complex in the whole realm of sound.

In the act of speaking the vocal cords cause air vibrations, which, falling upon the drum of the ear, are recognized by the auditory

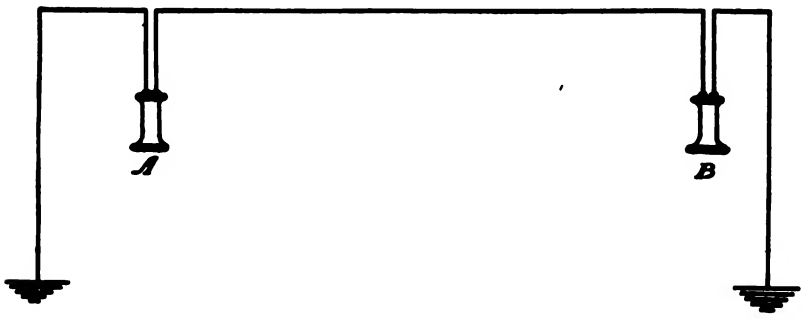

FIG. 32.

nerves as speech. If, instead of falling on the eardrum, these vibrations should fall upon a diaphragm which is capable of changing them into electrical vibrations, and there is some means of transmitting them along the line and again reproducing them at the other end into similar air vibrations, we have the telephone. In order to understand the action of the telephone it is necessary to define lines of force and explain two simple laws of magnetic induction. Lines of force are imaginary lines which surround a magnet and indicate by their position and number the direction and strength of its action. The laws of magnetic induction referred to are: First, if a number of lines of force thread or pass through a coil of wire and this number is increased or diminished, a momentary current will flow in the coil; second, if a coil of wire be wound around a permanent steel magnet and a current of electricity be sent through the windings, it will, if in a certain direction, increase the strength of the permanent magnet, and if in the opposite direction will diminish its strength. To understand how articulate speech is transmitted by means of the telephone, let us take the simplest case of two telephone receivers, A and B, connected to the line as shown in the figure above:

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The telephone receiver (a more detailed description of which will appear later) consists of a soft iron diaphragm placed close to a permanent magnet. Around the diaphragm end of this magnet is wound a coil of fine insulated copper wire. The air vibrations, caused by the act of speaking, upon striking the iron diaphragm at A cause it to vibrate. The vibrations of this diaphragm produce changes in the number of lines of force which thread through the windings of the coil. These changes, according to the first law, produce a current in the winding which will be of greater or less strength and in opposite directions, following the vibrations of the diaphragm. This varying current proceeds along the line, and when it arrives at B will increase and diminish the strength of B's magnet. The variation of the strength of B's magnet will produce a varying pull on B's diaphragm and cause it to vibrate in a manner similar to the diaphragm of A. The vibration of the diaphragm at B is recognized as sound coming from A. The simple circuit shown in figure 1 would permit a person to talk or hear, as the case may be. The first modification of the circuit (see below) is to introduce two telephone receivers at the point A and two at the point B, all being in series, one serving as the transmitting and the other as the receiving instrument at each point.

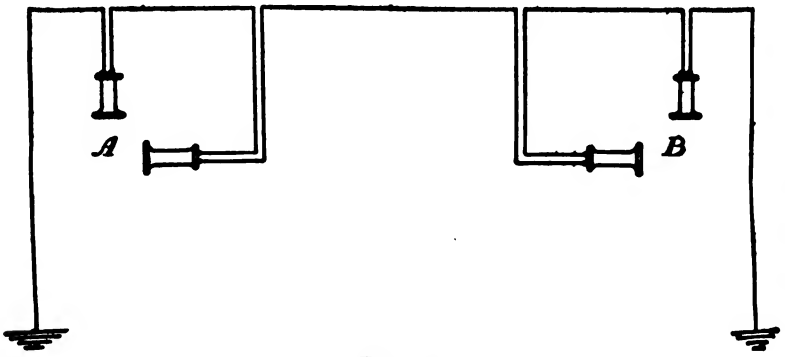

FIG. 33.

For certain reasons this type of receiver just described does not make a good transmitter, and in practice is replaced by a battery transmitter.

The Telephone Receiver

The telephone receiver consists of a U-shaped permanent magnet (t), to the ends of which are fastened soft-iron pole pieces (pp). Over each pole piece is a coil of fine wire wound on a bobbin with

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non-magnetic metal heads. These coils are connected in series in such a manner as to make the front end of one the north pole and the similar end of the other the south pole when current flows through both coils in a certain direction. The pole pieces pass through the bottom of a metal cup (c), which is thus secured firmly in place. The diaphragm (d), of soft iron, tinned or enameled, rests on the rim of this cup. A clamping ring (f) screws on the metal cup (c), thus holding the diaphragm (d) firmly in place. The receiver cords are connected to terminals (m), a strain cord being attached to the loop of the magnet to provide against injury to the cord conductors. As thus assembled the receiver is operative and may be so used in case of accident to the containing shell and cap. This shell (s) slips over the working parts of the receiver and is held in place by the earpiece (g), which screws on the shell. The separation of the diaphragm from the pole pieces varies with the different types of receivers, the usual separation being about 0.014 inch.

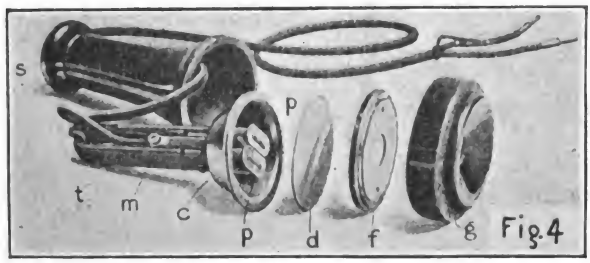

FIG. 34.

The Operation of the Receiver is as Follows:

The pole pieces (pp), being attached to the ends of the permanent magnet (t), have one a north and the other a south polarity, and the magnetic circuit is completed from one pole to the other through the soft iron diaphragm (d), which is, therefore, drawn toward the poles and held in constant tension. If a current flows through the coils in such a direction that the lines of force due to it coincide with those of the permanent magnet, the diaphragm will be pulled closer to the pole pieces, due to the increased strength of the magnetic field. If the current flows in the opposite direction, the strength of the magnetic field, due to the permanent magnet, will be reduced and the diaphragm will spring farther from the poles. It will thus be seen that whether the lines of force due to the current in the coils assist or oppose those due to the permanent magnet, a varying pull is produced on the diaphragm that causes vibrations in the latter in

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unison with the changes in current. The movement of the diaphragm will thus set up vibrations in the surrounding air which may be perceived as sound.

The Telephone Transmitter

The operation of the transmitter depends upon the fact that the electrical resistance between two or more bodies, either in light or loose contact, varies with changes in the pressure between the bodies. The change in resistance is due to variation in the area of contact surface between the granules and electrodes and not to compression of the carbon granules themselves. In general, the transmitters used by the Signal Corps depend upon this principle. A typical transmitter is shown below. A metal cup (A) forms the front electrode and is attached to the diaphragm for sending. The rear electrode is held rigidly in a metal bridge piece (F), which is in turn fastened to the frame which supports the mouthpiece (G) and the remainder of the transmitter. This rear electrode consists of hard, polished, carbon button (M), secured to a brass button between two parts of which is clamped a mica ring or diaphragm (O), the outer edge of which is clamped against the front electrode (A) by means of a metal ring (S), which screws over (A). The space between the front and rear electrodes is partly filled with hard granular carbon of uniform size. Two dampening springs, (B) and (C), are provided to prevent vibration of the diaphragm at its natural period.

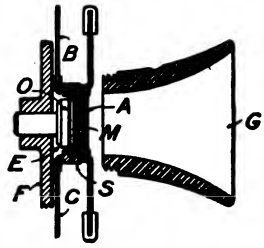

FIG. 35.

The Operation of the Transmitter is as Follows:

Current from a battery passes from one terminal (E), to the carbon electrode through the granular carbon to the metal cup which forms the other electrode. If the transmitter now be spoken into, the diaphragm and cup vibrate in unison with the sound waves produced in the air, thus causing the pressure between the front and rear electrodes on the granular carbon to vary and thus change the

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resistance of the transmitter. Therefore, variations in the current are set up which correspond exactly with the voice vibrations which reach the transmitter diaphragm.

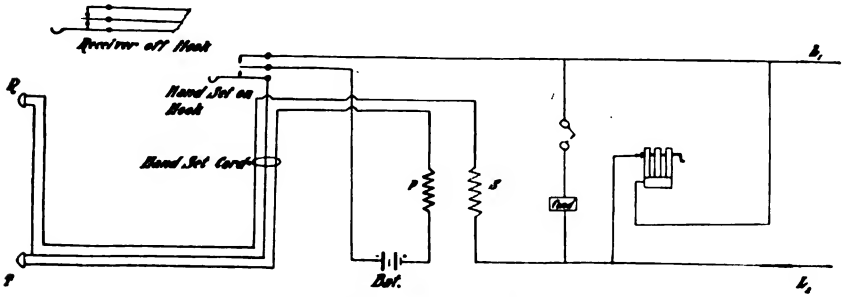
The Local Battery Telephone

Circuits of the local battery telephone are as follows, reference being made to cut below.

There are two circuits in the diagram which can be considered separately.

First, the primary or transmitter circuit, which is composed of a transmitter battery and the primary of the induction coil.

Second, the secondary or receiving circuit which is composed of receiver and the secondary of the induction coil and also includes the connecting line to the other station.



Camp Telephone
Model A

FIG. 36.

Being Called.—Hook switch contacts would be open, as in diagram, as receiver would not be removed from hook of hook switch. Magneto generator current enters at L_1, to ringer, to L_2.

Calling Distant Station.—Hook switch contacts would be open as in diagram, as receiver would not be removed from hook of hook switch. Revolving crank of magneto generator contact at C is closed and circuit is C to L_2 through one side of line, to ringer of distant station, through other side of line, L to A.

It will be noted that ringer of station calling will also be operated. The magneto generators are capable of operating forcibly under usual line conditions approximately ten ringers.

Listening.—Hook switch contacts are closed, as receiver should be removed from the hook. A high frequency alternating current from a distant telephone entering at L passes through the secondary of the induction coil, receiver, and the hook switch contacts to L.

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Talking.—Hook switch contacts are closed as receiver would be removed from the hook. Direct current flows in primary circuit as follows: Battery, hook switch, transmitter, and the primary of the induction coil. Voice waves fall on diaphragm of transmitter, varying the strength of the current in the primary circuit, thereby inducing in the secondary of the induction coils a high voltage and high frequency alternating current which is transmitted to a distant receiver by means of the following circuit: Secondary of the induction coil, receiver, hook switch to L, through circuit of the distant telephone, returns to L, and to the other side of the secondary.

The Camp Telephone

This telephone, which supersedes the field telephone, was developed by the Signal Corps for use in connection with camp telephone systems and small arms target range systems, and may be

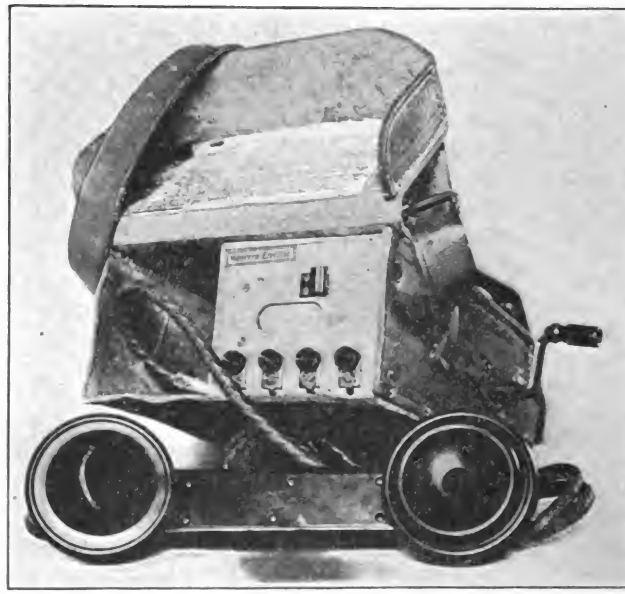

FIG. 37.

installed in tents and structures, or considered a portable instrument for use in the field for testing lines or other purposes.

It is of local battery type. The battery employed is one unit of tungsten type A which is made up of two small cells so placed in a rigid paper tube that they are connected in series. The combination gives a total voltage of 3—1½ being normal voltage of each cell.

The instrument is made as compact as practicable and is con-

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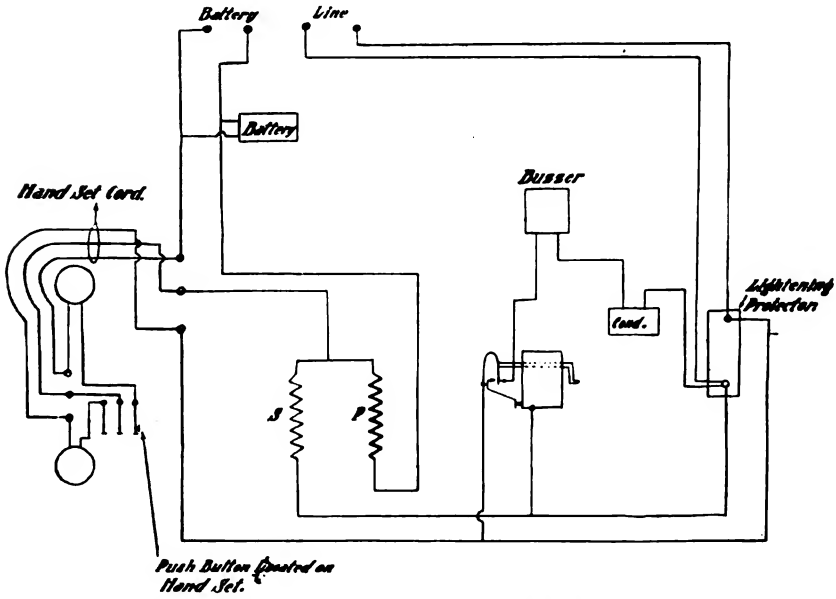
tained in an oak case 4¼ by 7 by 10 inches high. The top consists of a metal hinged cover with circuit diagram on inside, held rigid when closed by a spring snap which can be readily released by depressing a button. The bottom of case is covered by a flanged piece of metal, the flange projecting approximately one half inch up sides of case. Through one side of case are six three eighths inch holes which are covered on the outside by a close mesh metal screen



Simplified Wiring Diagram
W.E. Telephone.

FIG. 38.

held in place by a metal frame. These apertures are for the purpose of allowing the ringer to be distinctly heard. The case is equipped with a substantial, adjustable carrying strap, each end of which is fastened to case by means of hinged metal rings.

A small 3-bar magneto generator, small ringer, induction coil, aluminum chamber for the single unit of tungsten type A dry battery, hard rubber block upon which are mounted line binding posts, plug connections for the hand set used with the instrument, hook switch and hook operating it, and auxiliary battery binding posts are all mounted on a common base which may be readily removed from case after removing magneto generator crank, metal housing for it, and three screws which extend through the case.

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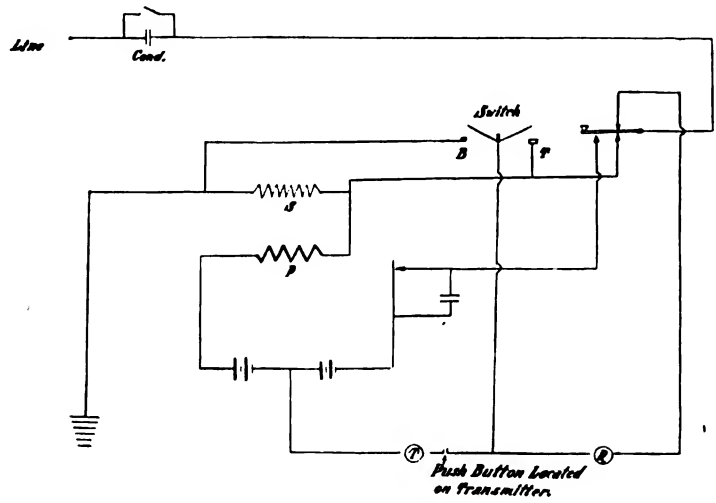
. The instrument may be operated with cover closed which is highly advantageous in inclement weather. To accomplish this there is a suitable opening for leading out the 3-conductor cord to receiver and transmitter, the two latter being mounted in the form of a unit, termed a hand set. This hand set consists of a transmitter and a receiver mounted on a metal piece and is so designed that when the transmitter is normally placed to the mouth, the receiver is automatically adjusted to the ear.

The hook of hook switch is so designed that it protrudes through case. When it is desired to transport the instrument or to remove



Simplified Diagram of Connections Service Buzzer, Model 1914.

FIG. 39.

the base upon which is mounted all the parts of the instrument, it is merely necessary to depress the hook and push it toward the base. By this arrangement the hook is not only held in the down position, thereby opening the battery circuit, but it is also protected.

The aluminum chamber for housing the single unit of tungsten type A battery is equipped with a spring catch so located that when upper hinged piece is depressed to proper position, the battery compresses a helical spring, thereby insuring continual contact. The base is equipped with two screw binding posts which may be used to connect leads to an outside battery in the event of there being no tungsten type A batteries available.

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An aluminum frame which is supported on the base previously mentioned forms a compartment for the hand set when instrument is being transported. When the instrument is installed for a temporary period, unless in actual operation, the proper place for the hand set is hanging on the hook of hook switch, there being a ring on the hand set for this purpose.

A small screw driver which will fit practically all the screws used in the construction of the instrument is supported by the metal frame and is furnished with each instrument. The instrument complete weighs approximately eleven pounds.

Circuit Diagram of the Camp Telephone

It will be noticed that the diagram is an exact simile of the local battery telephone circuit as previously explained. The primary circuit consisting of transmitter, battery, and primary of the induction coil; the secondary circuit consisting of the secondary of primary of the induction coil and receiver of the line.

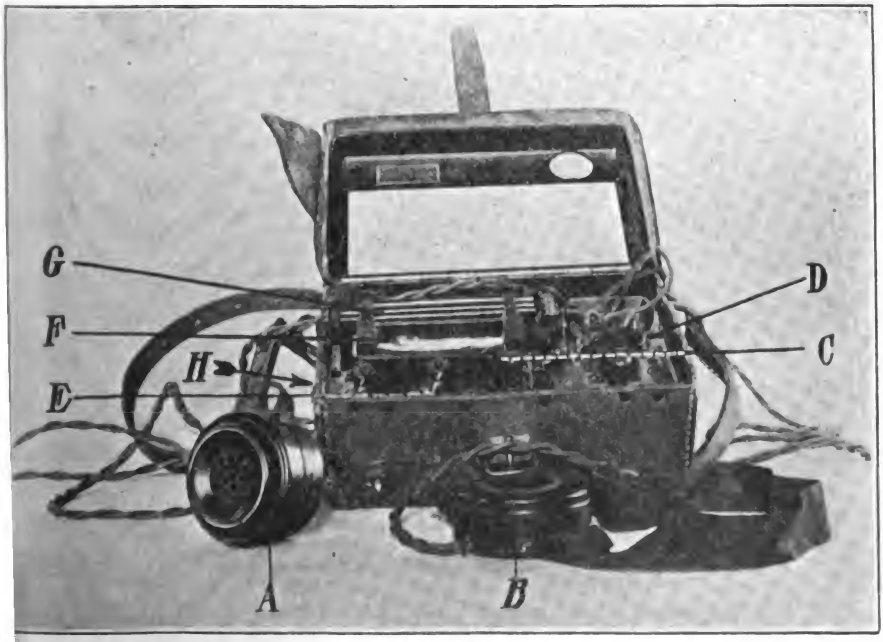

FIG. 40.—FIELD SERVICE BUZZER

A. Transmitter.
B. Receiver.
C. Telephone and Buzzer Switch.
D. Sending Key.
E. Line Binding Posts.
F. Induction Coil.
G. Condensers.
H. Line Jack.

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Common Faults and Remedies of the Magneto Telephone

The most common troubles in telephone instruments are due generally to one of three causes: (1) Loose or dirty connections at the binding posts of the instrument, at the binding posts of the batteries, or in joints in the line wires; (2) exhausted, poor, or weak batteries; (3) crossed, open, or defective wires. These troubles, of course, do not include those arising from inferior or defective instruments.

If the connections are dirty, corroded, or greasy, scrape the wires and clean out the binding posts; then, screw the wires firmly in place. If the telephone does not then work properly, examine the batteries and see whether they are run down, or whether the zincs are eaten away. With wet batteries, it may be possible that the water has evaporated; in dry batteries, the zinc may be eaten through, or the batteries may be otherwise defective. The simplest way to test the battery is to try a new battery, and see whether it will make the telephone work properly; if it does, the trouble is with the old battery. If the trouble is present after changing the battery, examine the line connections and the line outside; if any loose connections are found, correct them at once. When inspecting the line outside see that it does not touch anything except the insulators, and that it is neither crossed nor broken. On grounded lines—grounded lines are obsolete now in modern warfare on account of the many means of detecting and picking up messages now employed; in fact the metallic circuit telephone lines are now used within a mile of the front lines except for messages which would be of no value to the enemy—examine the ground connection the first thing and see whether it is in good condition; and if a plate is used, see that it is in moist ground.

A frequent trouble with transmitters is a frying noise; that is usually caused by induction or static electricity, and may also be caused by loose connections.

1. **Open Line.**
   Effect: Cannot receive a call or get central.
   Test: Follow line with portable magneto test set and ring: if central gets ring, open it toward station or vice versa.

2. **Open Battery:**
   Effect: Can hear and receive central call but cannot talk.
   Test: Strap out primary winding or transmitter with test receiver, and leaving receiver off the hook

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3. **Open Primary Winding:**
4. **Open Transmitter:**

at station, listen in either receiver for click while moving switch hook up and down. If no noise be heard, battery circuit must be open, and circuit should be followed across with test receiver, which will click loud where battery is found to be O. K.

5. **Short Circuited Line:**
6. **Wet or Short Circuited Instrument:**

Effect: No signal will show at magneto switchboard, and use of station instrument will be impaired and magneto will turn hard.
Test: Open line and ring; if magneto still turns hard, open connections one at a time, where available, throughout entire winding until magneto turns freely.

7. **Line Crossed with another Line:**
   Effect: Other talking heard on line when receiver is off the hook.
   Test: Ring magneto and with central's help try to locate other party; then trace line.

8. **Open Secondary Winding:**
9. **Open Receiver:**
10. **Receiver Diaphragm Missing or Badly Dented:**

Effect: Can ring and hear central ring but cannot hear in receiver although can be heard.
Test: Strap test receiver across open part.

11. **Weak Battery Cells:**
    Effect: Can hear well but cannot be heard clearly.
    Test: Use ampere meter and see if each cell be weak.

12. **Open Bell:**
    Effect: Can talk and hear in receiver but bell does not ring.
    Test: Strap bell coils out with test receiver and listen in.

13. **Open Magneto Armature Winding:**
    Effect: Bell rings from central but does not ring when magneto handle is turned nor can central be called.
    Test: Ring with another magneto or test set.

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14. **Slight Short Circuit (escape) to Ground:**

Effect: Can ring operator but cannot hear nor be heard clearly.

Test: Open line, one line at a time, and follow circuit with test set. Escapes are due to wires touching damp walls, metal roof, or other grounded wire where insulation has been rubbed off.

NOTE.—(In lecturing on location of faults in electrical circuits it must be remembered that frequent or even constant recourse to the printed diagrams must be had as the student will not remember the various wirings and a verbal picture alone of the schematic system will not be sufficient. Use the diagrams and avoid a useless waste of time dealing with unnecessary questions.)

The Monocord Switchboard

The liaison of telephone intercommunication between army units is frequently such that a temporary, quickly installed, and flexible type of small central exchange located in the field, is essential. Such an exchange is usually placed in a well-protected dugout at the infantry battalion headquarters, artillery battalion headquarters, central artillery observation post, etc., where it will be the central terminal point of from four to twelve or more lines connecting with the headquarters of the higher command, with the several units attached to or working with the battalion, and with the adjoining similar battalions. The switchboard which has been designed to meet these requirements is called the "monocord switchboard," and is made up of either four, eight, or twelve of the type EE-2 switchboard units.

The monocord switchboard is made up of unit panels, on each of which is mounted all the apparatus necessary for the central exchange end of one telephone line. These panels are made of insulating material and are mounted in special wooden frames in groups of four, eight, or twelve units, according to the size of the installation necessary. The two sizes most commonly used in overseas work are the four-unit and twelve-unit boards. Each unit is removable from the frame, thereby lending flexibility to the board and facilitating repair and replacement. Generally, this type of board is used only for a small number of lines, as the operating facilities do not permit speedy connections, and it is always better practice to use only three lines on a four-unit board and eleven lines on a twelve-unit board in order to have a spare unit immediately

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available. Photographs of a four-unit board and of an individual unit are reproduced in Figs. 41 and 42.

The monocord switchboard may be used with either a magneto telephone, camp telèphone, field telephone, model 1917, buzzer-phone, or service buzzer. The operator's telephone set is not fur-

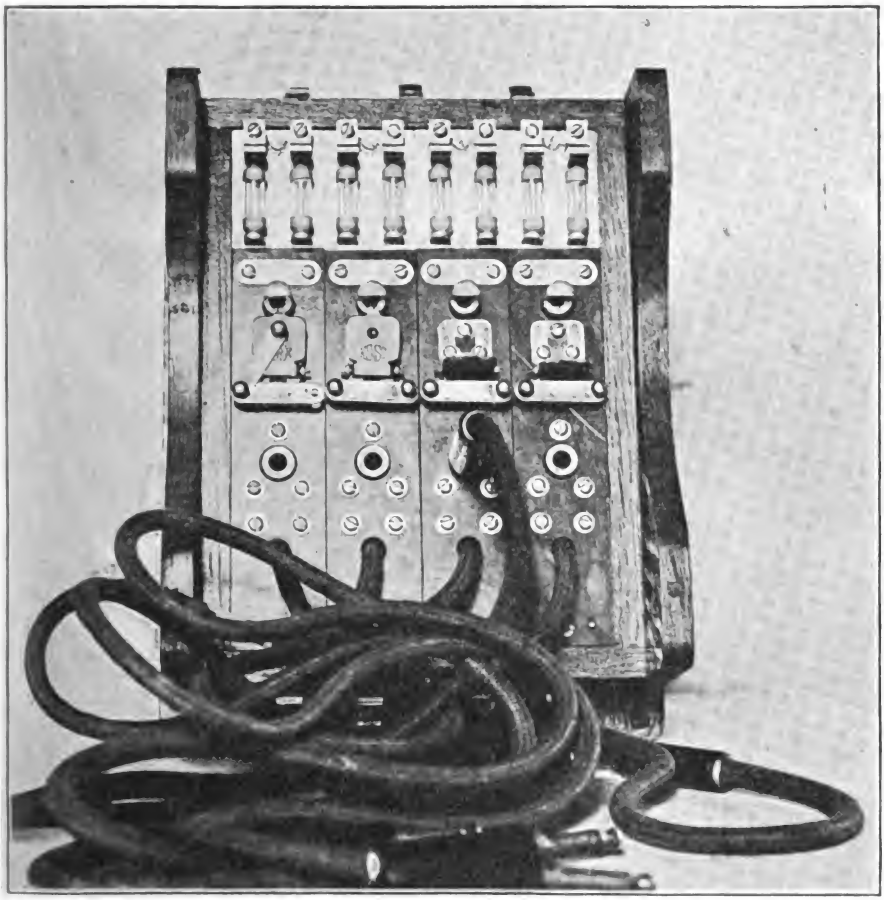

FIG. 41—FOUR UNIT BOARD

nished as a part of the switchboard and a separate telephone set of one of the type mentioned must be supplied for this purpose.

Switchboard Frame.—The switchboard frame is made of hard wood, varnished in order to make it moisture proof. Its function is to hold the various units together and to protect them from dust and mechanical injury. In back of the frame there are three horizontal brass bars extending the width of the board. In addition to

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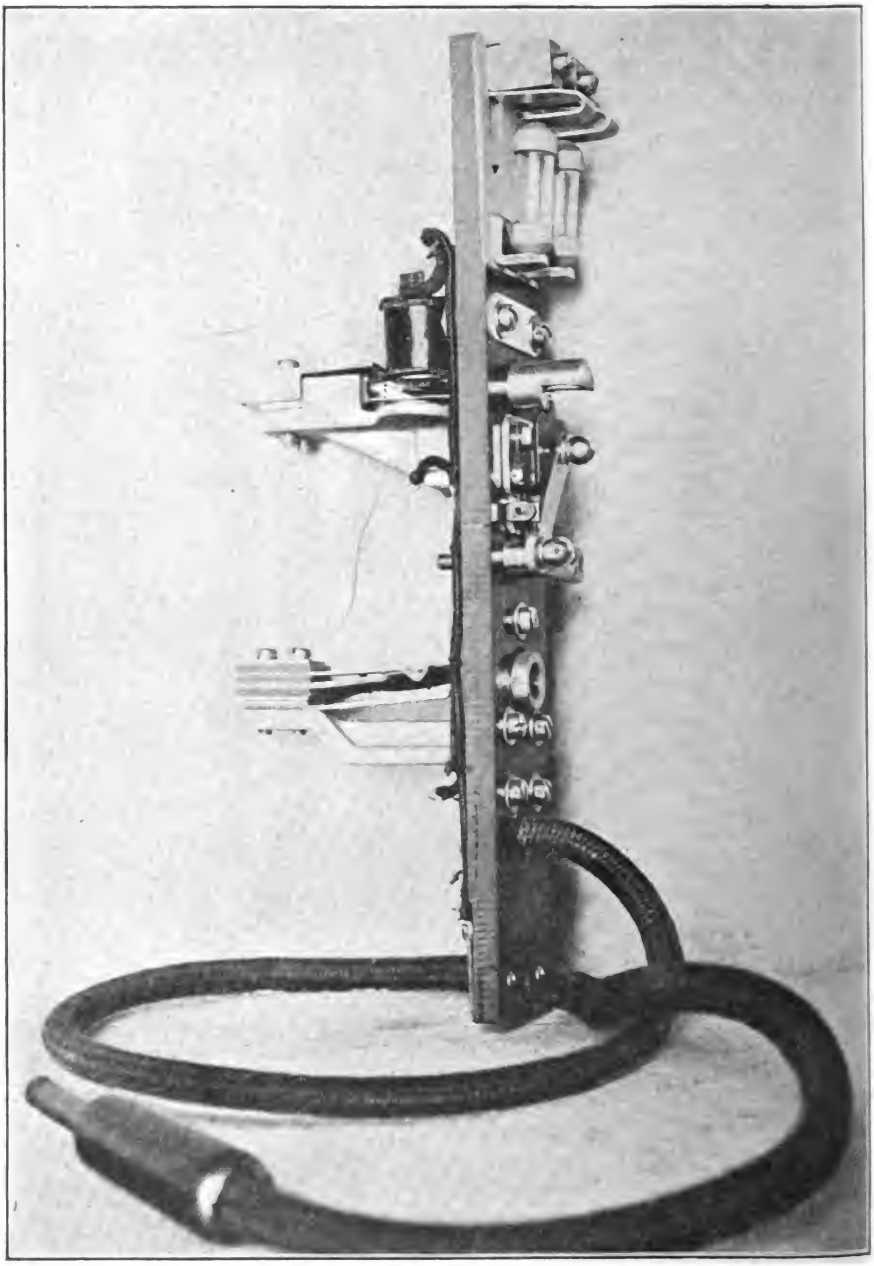

FIG. 42—INDIVIDUAL UNIT

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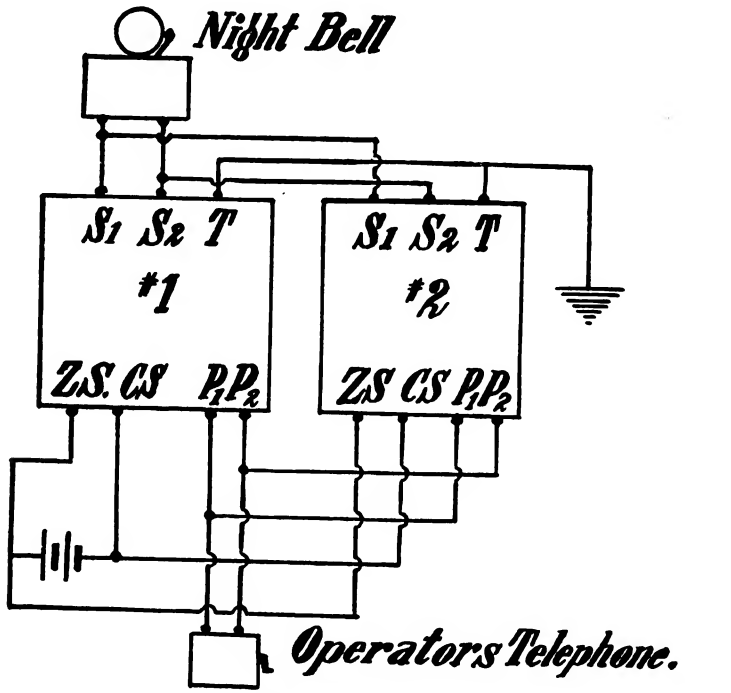
providing a mechanical support for the various units, the top bar serves as a common ground connection and the middle and bottom bars as common night bell and battery connections for all units. Three Fahnestock clips on American made boards and binding posts on French made boards are installed at the top of the frame and four at the bottom. On the French made boards the upper three



Method of Interconnecting Two Switchboards.

FIG. 43.

binding posts are marked S1, S2, and T, and are used for connecting by independent wires, respectively, the night bell and ground. The two posts at the bottom of the frame marked ZS and CS are used for connecting the two poles of the night bell battery. To the other two marked P_1 and P_2, are connected the operator's telephone set and the operator's plug. The terminals at the top of the American made boards are marked A, A1, and G, corresponding with the French S1, S2, and T, and those at the bottom are marked B, B1, L1, and L2, corresponding to ZS, CS, P_1, and P_2, respectively.

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If two or more multi-unit boards are connected in parallel for operation at one exchange, the interconnections between boards in order to use one ground, one night bell, and one battery for the whole exchange, are made as indicated in Fig. 43. The corresponding binding posts at the top and bottom of the frames are simply connected to each other, as S1 and S2 of No. 1 board to S1 and S2, respectively, of No. 2 board.

Unit Panel.—Each unit comprises all the necessary apparatus for the exchange terminals of one line (two wires). A skeleton drawing of a unit is given in Fig. 44 and the various parts are listed below according to their position on the panel from top to bottom:

Two connecting blocks for the line wires
Lightning arrester between these blocks
Two fuses
Line number plate
Line drop signal and night bell contact
Jack
Cord and line plug

Each unit is held in the frame by means of two machine screws, one at the top and one at the bottom of the unit, which engage the brass bars in back of the board and hold the unit firmly in place. Rigidity of construction is essential as constant use and transferring from one place to another tend to loosen the units from the frame and disturb the sensitiveness of the adjustment of the line drop.

Lightning Arrester.—The lightning arrester is a simple toothed washer held against the panel by the upper supporting screw. This screw is grounded through the upper brass bar. If lightning comes in on the line wires, the main portion of it jumps the small air gap from the binding post to the grounded washer and thence passes to ground, so that only a small portion of the high frequency current flows through the switchboard apparatus. If the latter portion is at all heavy, the fuses burn out, opening the circuit through the switchboard with a much wider gap and hence higher resistance than that in the circuit to ground across the arrester.

Line Fuses.—Two glass-enclosed removable fuses, which fit into spring connections, are provided to protect each side of the line from excessive currents. In order that burned out fuses may be readily seen, the panel is painted white behind them. The glass is usually smoked up more or less when a fuse burns out and this against the white background is quickly noticed.

Line Number Plate.—The line number plate is a small white celluloid strip on which the line number is written. This number may easily be erased if it is necessary to change it.

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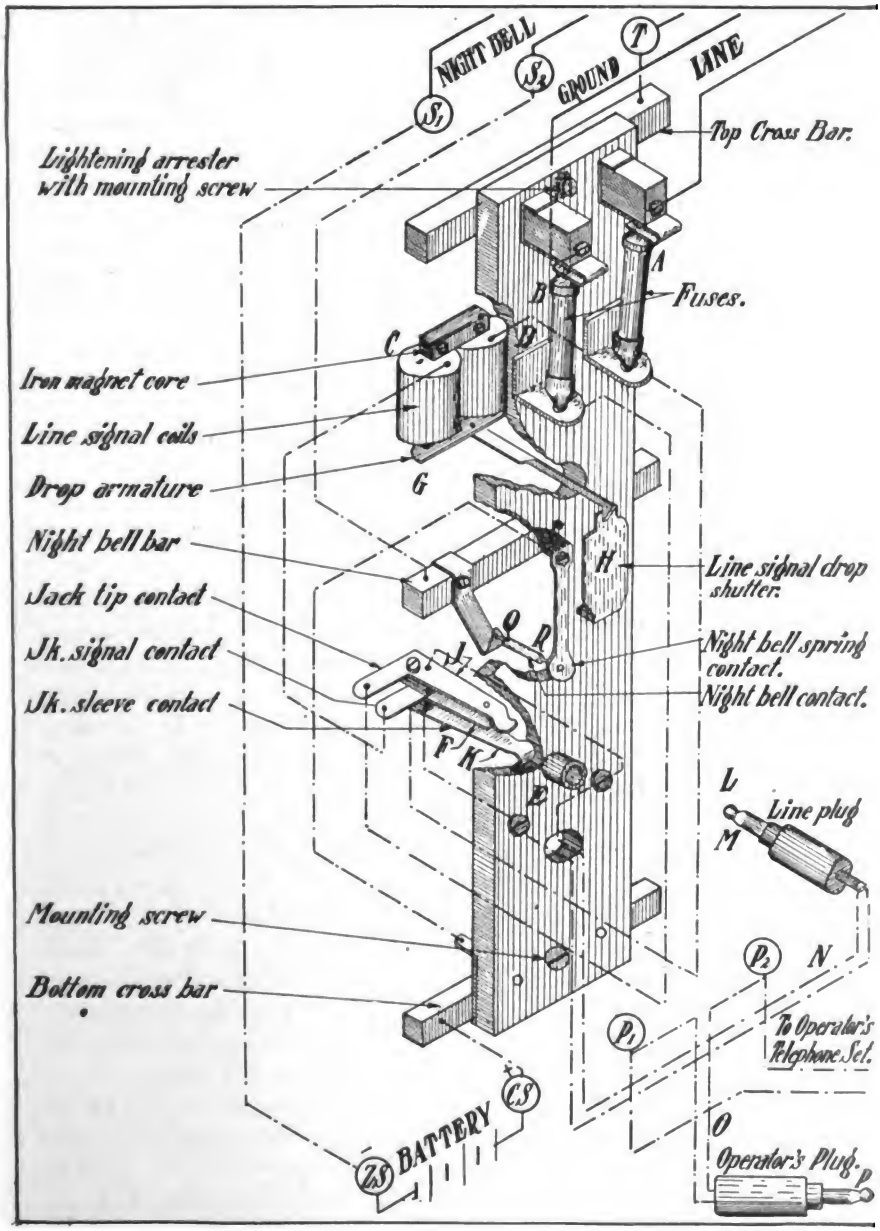

Skeleton Drawing of a Monocord Switchboard Unit.

FIG. 44.

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Line Drop Signal.—The line drop signal consists of a shutter H, Fig. 44, held normally in a vertical position by a brass trip latch. This trip latch is attached to the armature G of a small electromagnet C, which is normally connected across the line through the anvil and the jack tip contact spring of the switchboard jack. When the coils of the magnet are energized by a current sent over the line from a calling station, the armature and trip latch are lifted, thereby releasing the shutter which falls by gravity to a horizontal position and attracts the attention of the operator. The electromagnet is adjusted to operate on a very small current. For locking the shutter in the vertical position and protecting it from mechanical injury during transport, a flat spring lever is provided which may be turned in the vertical position and protecting it from mechanical injury up from a pivot at one end to press against the shutter. One of these levers is shown so adjusted at the first unit at the left, Fig. 41.

Night Bell Spring Contact.—The night bell contact Q, Fig. 44, is located in back of the panel. The battery and bell circuit through this contact is closed when the line signal drop shutter is released by the electromagnet, this forcing the spring R back against the contact point Q. The night bell spring contact R consists of a narrow flat brass spring, screwed at one end to the drop mounting plate. The contact point Q is mounted on the back of the panel, the rear end of this rod making contact with the night bell bus bar, against which the rod presses when the panel is screwed in place on the bars along the back of the switchboard. This construction is shown clearly in Fig. 44.

Switchboard Jack and Line Plug.—Each unit is provided with a jack and plug. The jack consists of a cylindrical opening E in the panel of the unit, behind which are arranged the tip contact spring J, the sleeve contact spring K, and the anvil F. The tip spring is connected through one of the fuses to one of the line wires. The anvil is connected to the other line wire through the electromagnet coils and the other fuse. The magnet circuit is normally closed across the line when there is no plug in the jack, as the tip spring and the anvil are then in contact. A current coming in over the line, then, would energize the coil. The sleeve spring of the jack is connected directly to the same line wire as the anvil. The line plug is bridged across the tip and sleeve contact springs. It is a standard two-contact type, the tip and the sleeve making direct connection to the line. This is shown fully in Fig. 44.

Operator's Equipment.—Any equipment which is not individual to a line, but which is used in common to all lines in the process of interconnection, is called the operator's equipment. This consists

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of an ordinary telephone set, employing either magneto or buzzer and including a transmitter, receiver, induction coil, generator, battery and connections, together with the wiring and associated parts necessary to coördinate them with the rest of the apparatus. An operator's equipment also includes a night bell and bell battery.

Carrying Case.—Carrying cases made of fiber and provided with hand straps are furnished with monocord switchboards to provide a convenient means of carrying them and to protect them from damage during transportation. These cases are made so that they will hold not only the frame with the assembled units, but also the switchboard cords. To move the board it is necessary to disconnect the night bell battery, the night bell, the ground connection, the operator's set, and the several line wires.

Care and Adjustments.—Care must be exercised when a board is installed to make sure that the frame is in a vertical and level position. When assembled at the factory, all adjustments are made with the board in a vertical position and all operations conductive to satisfactory service depend on this prerequisite being observed.

The line signals of monocord switchboards are of the gravity type and require careful adjustment. Any adjustment further than that done at the factory should be made by an expert who is thoroughly familiar with this work. During transportation and installation of the board, the line drop shutters should be held closed by the flat spring previously described.

The burning out of a fuse when excessive current comes in on a line is detached by an open circuit on that line. A bad fuse generally shows up plainly against the white background on the panel. However, if it is not possible to see whether or not the fuse is burned out, the line may be short circuited momentarily by means of a piece of bare copper wire placed across the two line terminals. The operator's plug is then inserted in the jack of the unit under test, and the magneto crank turned. If the fuse is burned out, the crank will turn over easily; if not, it will turn hard, indicating that the open circuit is elsewhere on the line. A burned out fuse should be replaced immediately in order to keep all lines working. Several spare fuses should be kept on hand at all times, but in case no fuse is available, a strand of small copper wire may be connected across the upper and lower fuse clips. To remove a fuse, take the bottom metal cap of the fuse between the thumb and finger and push upward against the spring holder on the line terminal block, at the same time pulling outward. To install a fuse, hold it in the same manner and put the other end of the fuse in the upper spring contact, forcing it upward until the bottom end will slip into place.

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Care should be taken to keep the small air gap between the toothed washer and the line terminal clean. If this precaution is not taken, and the air gap is allowed to clog up with dust and dirt, it will introduce a leak to ground or between wires with resulting poor transmission.

All mounting screws and all wire connections should be kept tight. Whenever a unit is damaged, it should be replaced by another one, the damaged unit being sent back to headquarters for repair. In this connection it should be noted that the American unit panels and parts have been made interchangeable with the French to facilitate repair. To remove a unit from the frame, it is only necessary to disconnect the line terminals and remove the top and bottom screws which engage the brass bars behind the board.

In handling the switchboard cords, they should be grasped by the plug, not by the cord. The connections of the wires to the tip and sleeve of a plug will break if subjected to undue strain or abuse, and by taking hold of the plug when inserting it and pulling it out, the likelihood of breaking the internal connections and wearing out the wires will be reduced to a minimum.

Disadvantages of the Monocord Switchboard

1. It does not afford as quick connections as the bi-cord type switchboard.
2. It is not self-contained. A self-contained switchboard includes operator's receiver and transmitter, and ringing and night alarm circuits.
3. The operator's telephone is usually equipped with a hand set (receiver and transmitter) which leaves him only one free hand for making connections.
4. One switchboard is equipped with but one master, or operator's cord, this affording but one means of answering and calling.

Advantages of the Monocord Switchboard

1. Small, compact, light weight.
2. Simple wiring.
3. Quickly installed.
4. Particularly suited for small central exchanges.
5. Units can be removed quickly in case of trouble in interior circuits. Any unit can be removed without disturbing other units.

The line may become grounded between the lightning arrester and line terminal. To clear, move the arrester so that there will be

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a small space between its points and the terminal, and clear away any particles of dust and dirt.

If the night alarm continues to ring after the drop signals are returned to normal position, it will probably be found that the trouble is caused by the contact spring R touching the contact point Q. To clear, adjust the spring to allow a small space between contact points.

If the armature does not lift high enough to release the drop, remove the unit and see that the armature is properly adjusted.

A common source of trouble may be an open wire in the magnet coils or between these and the line or jack. Or the tip spring of the jack may not make contact with the anvil. In the first case, the trouble may be cleared by replacing the whole unit. In the second case, the trouble may be remedied by adjusting the tip spring and cleaning the contacts.

To test for an open circuit in the cord of any unit, disconnect the line wire from the unit in question, place the operator's plug in the jack of the same unit, and take hold of the plug of the unit under test so that the fingers will touch the sleeve and the tip of the plug. Then ring the operator's set. If there is a break in the cord the current will not be felt in the fingers.

The operator's cord is used more than any of the other cords, and is consequently subject to more frequent trouble, the trouble usually being an open circuit. The operator's cord can be tested by holding the plug in the hand so that the fingers will touch the tip and sleeve, the operator then turning his magneto.

Should the operator's cord be found defective, operation of the switchboard can be continued in the following ways:

1. Transfer the wires from P_1 and P_2 to the line terminals of a unit not in use, and use the cord of this unit as the operator's cord while the latter is being replaced. If a spare plug is on hand, insert it in the jack of this unit and disconnect the signal drop coils from their connections across the line. In case no other method can be used, and there are two lines which are not used much, connect them both to one unit, thus leaving a free unit. When this is to be done, the parties on both lines should first be notified. Connections are then made to the free unit as noted above.

2. Connect the terminals of an extra cord direct to the terminals of the operator's set, and use this as the master cord while replacing the defective one.

3. If an extra plug is available but not extra cord, and there are no spare units on the board, remove the paper sleeve from the handle of the plug and transfer the wires from P_1 and P_2 to the

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terminals of this plug. This plug can then be used as master plug until repairs can be made.

To replace the operator's plug, remove the two units to the right of the point where the cord goes up through the bottom of the board. This will give access to the cord connections desired. Extra cords and extra units should always be kept on hand, or where they will be available on very short notice. This will avoid any serious delay in communications where the lines are relied upon for important work.

Aeroplanes

While occupying a position and during movements, aeroplanes are assigned to work with the various artillery units. These planes are in addition to those used by the infantry and the higher commanders, and are readily distinguished from them by markings and also by the courses pursued by them in carrying out their work. In general the principal uses of the artillery plane are reconnaissance and observation of fire.

Under the head of reconnaissance are included general observation of the enemy position, and movements, specific location of existing or possible objectives, location by map coördinates usually being employed. This work is usually done more or less deliberately depending on the activity of the sector and the degree of air superiority.

Observation of fire, as the name implies, is the acquisition and transmission of information upon which the officer conducting the fire may base corrections to secure a proper adjustment or a more effective fire.

For these duties, an observer, usually an artillery officer, is specially trained.

Communication with the ground is maintained by:

(a) Radio. Each plane is equipped with a transmitting set the messages from which are received at the battalion firing. The pilot and the observer in the plane are connected by phone, and the set may be operated by either. The messages are sent according to a standard system of codes, to prevent their being understood by the enemy.

Radio telephony and radio reception are being developed for use in planes but up to the present time are not in general use.

(b) Panels. The two general types of panels used by artillery are the identification, by which the observer can locate the units, and the rectangular which, used

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in conjunction with the identification panels, enables the ground station to acknowledge or send messages according to a prearranged plan.

A shutter panel, designed to show alternate light and dark surfaces is sometimes used, but results are not entirely satisfactory.

(c) Fireworks. Short messages according to prearranged code are exchanged between aeroplane and ground by means of fireworks (Very lights and rockets).

(d) Weighted message tubes. Written messages and maps in a weighted tube are frequently dropped from a low altitude to a ground receiving station. To the tube is attached a streamer to mark its fall.

(e) Carrier pigeons are occasionally used from plane to ground, but as lofts are generally at large headquarters the messages must be relayed and are frequently delayed.

(f) Sound and light signals (projectors) are sometimes employed but owing to difficulties of operation are not particularly satisfactory. Use of these however may be made to attract attention of plane.

The instructor will secure three rectangular panels and one identification panel and will explain the operation of the panel details.

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CHAPTER IX

ORIENTATION AND TOPOGRAPHY

IN open as well as in trench warfare every officer, particularly every artillery officer, should have a thorough knowledge of maps. He should be able to read maps quickly and accurately. An officer unable to read a map is unfitted for his duties. By learning how they are made and by making them the student will learn how to read maps.

Military Topography can be divided under two heads:

(a) A Military Map is a projection to scale of the topographical features of the ground, made with exact instruments, without haste, and its usefulness is dependent on its accuracy and completeness. In general, military mapping is the business of the engineering corps.

(b) A Military Sketch is a graphical report of the features of a section of country in which certain conventional signs are substituted for words. Its accuracy is dependent on the time available, the instruments at hand, and the tactical conditions.

All mapping and sketching is fundamentally the location of one point with respect to another as regards distance, direction, and elevation.

A few fundamental definitions and terms—the alphabet of mapping—are set forth below:

The Direction of one point from another is the angle in the horizontal made by the line joining the two points with a vertical plane coincident with the magnetic meridian passing through one of them. The angle called the **azimuth** is always measured in a clockwise direction in degrees, mils, grads, or any convenient unit of angular measurement. It is well to know that 1 mil equals 3.375 minutes or $\frac{1}{16}$ grad.

Distances between points are ordinarily measured in sketching by the stride of a man or a horse or by the revolutions of a wheel with an odometer attached. In mapping, more accurate means are used: tapes, chains, etc.

There are three ways by which the scale of a map may be represented and distances measured on it.

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1. **By words and figures:** 1 in. = 1 mile. Or 1 meter = 60 kilometers.
2. **By representative fractions:** 1 = 63,360, meaning 1 inch on map equals 63,360 inches on the ground. Or, similarly, 1 = 60,000, meaning 1 meter on the map equals 60,000 meters on the ground.
3. **By graphical scale:** that is, a line drawn on the map and divided into equal parts, each part being marked with the distance which it represents on the ground. This method is good in that the scale shrinks and expands with the map.

Elevation of one point with respect to another is measured by the angle formed by the line joining the two points and the horizontal plane through one of them. This angle is measured in the vertical and is called a **gradient.**

Gradients are commonly called **grades** or **slopes** and are expressed in several ways, as follows:

1. **In degrees:** as, for instance, a "1 degree slope," meaning the angle between the horizontal and the given slope is 1 degree.
2. **In percentage:** a slope of 1%, meaning that the ground rises 1 foot in 100 feet or 1 yd. in 100 yds., etc.
3. **In gradients:** a slope is said to be 1-100 when one vertical corresponds to 100 horizontal. That is, the ground rises 1 foot in every 100 feet measured horizontally.

Elevation is represented on the map by means of hachures, or contours, the former being only a means of indicating in a general way the form and steepness of the slopes, while the latter not only give all the information which the former can convey but by the very method of their construction give an accurate means of reading the grades and elevations. The contour line may be defined as a line each point of which has the same elevation. The vertical distance between adjacent contours is known as the vertical interval (V. I.).

In order that our maps may be easily read, they are made according to a uniform system of scales and contour intervals:

(a) For route maps of extended marches: Scale 1 in. equals 1 mile; V. I. equals 60 ft.

(b) For ordinary road sketches: Scale 3 in. equals 1 mile; V. I., 20 feet.

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(c) Position and outpost sketches: 6 in. equals 1 mile; V. I., 10 feet.

(d) Siege operations: 12 in. equals 1 mile; V. I., 5 feet.

The metric system is used in French maps. The scale of the most widely used maps is 1 = 10,000, V. I., 5 meters; 1 = 20,000, V. I. 10 meters.

There are five kinds of military sketches:

1. **Position or Area Sketch:** This is a sketch of an area to all parts of which the sketcher has access. Scale usually 6 inches to the mile: V. I., 10 feet.

2. **Outpost Sketch:** In which the sketcher travels along and in rear of the outpost line, sketching the area to the front. Scale: 6″ to the mile V. I., 10 ft. It is an outline of the enemy position made from the friendly lines and is usually combined with a position sketch.

3. **Place Sketch:** Where the sketcher is located in one place on a hillside or other high point in a restricted area and from which he sketches the ground to the front and flanks. It is akin to the outpost sketch but made from one position. Scale: 6″ to the mile, V. I., 10 ft.

4. **Road Sketches:** usually made mounted, preceding the column, and the sketcher sending back the sketches as promptly as possible so that the commander may use the information contained in them on the march and in making disposition of his troops. Scale: 3″ to the mile.

5. **Panoramic Sketches:** or landscape sketches, which are to the artilleryman of great value as a means of target designation.

Conventional Signs

Those used and authorized in the military service are illustrated in Field Service Regulations. A sketch is made primarily to convey certain information. Always remember that the sketch is being made to read; that the convenience of the reader is sought, not that of the sketcher; that it is worthless to put a mark on a sketch unless that mark has a meaning which the reader will be able to make out.

Anyone who has the ability to read and write should be able to learn to sketch. In sketching, as in writing, however, the signs have to be learned and facility in making them has to be gained before much can be accomplished. Much time is wasted in the field by beginners on account of the fact that they have not sufficient famil-

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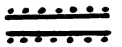
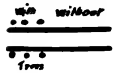
FRENCH CONVENTIONAL SIGNS.


National Highway



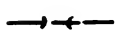
Constructed Roads
Always passable

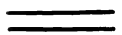
Second Class Roads
Passable Dry Weather

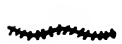
Country Roads

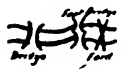
Trail

Path


Single Track RR


Double Track RR


Narrow Gauge RR



Rivers

Creeks

Walls

Hedge

Wood Fence

Wire Fence

Ditch

Embankment

Geodetic Point

Church

Cemetery

Windmill

Water Wheel

Geodetic Point

Gardens and Orchards

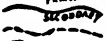
Groups of Trees

PLAN DIRECTEUR

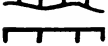
Trench Without Loopholes

Trench With Loopholes

Communication Trench
" "


Abandoned Trench

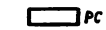
4 Gun Emplacement


Battery Position

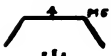
Anticraft Gun

Works - Redoubts
Dugouts - Shelters

Observation Posts



Command Posts



Machine Guns. (Arrow Direction of fire)

Single Gun
Standard Gauge R.R.
Narrow Gauge R.R.

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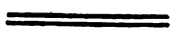
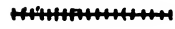
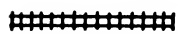
CONVENTIONAL SIGNS U.S.ARMY.


IMPROVED ROAD

UNIMPROVED ROAD

TRAIL


SINGLE TRACK RAILROAD

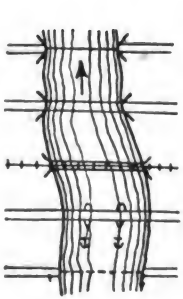

DOUBLE TRACK RAILROAD

TELEGRAPH LINE

TELEGRAPH LINE ALONG IMPROVED ROAD

STREAMS

INTERMITTENT


FOOTBRIDGE

ROAD BRIDGE

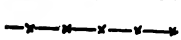
RAILROAD BRIDGE

PONTOON BRIDGE

FORD

FENCES

SMOOTH WIRE


BARBED WIRE

WOOD OR RAIL

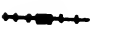
HEDGE

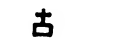
STONE

WOODS

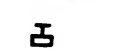
ORCHARD

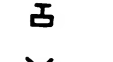
LAKE OR POND


RAILROAD STATION


CHURCH

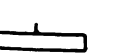
P.O. POST OFFICE


TELEGRAPH OFFICE


WIND MILL

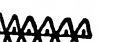
TRENCH

BARBED WIRE ENTANGLEMENT


INFANTRY

CAVALRY

ARTILLERY


CAMP

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iarity with the conventional signs and abbreviations to enable them to put down the right one quickly.

A.	Arroyo.	G. S.	General Store.	Pt.	Point.
abut.	Abutment.	gir.	Girder.	q. p.	Queen-post.
Ar.	Arch.	G. M.	Gristmill.	R.	River.
b.	Brick.	I.	Iron.	R. H.	Roundhouse.
B. S.	Blacksmith Shop.	I.	Island.	R. R.	Railroad.
bot.	Bottom.	jc.	Junction.	S.	South.
Br.	Branch.	k. p.	King-post.	s.	Steel.
br.	Bridge.	L.	Lake.	S. H.	Schoolhouse.
C.	Cape.	Lat.	Latitude.	S. M.	Sawmill.
cem.	Cemetery.	Ldg.	Landing.	Sta.	Station.
con.	Concrete.	L. S. S.	Life-saving Station.	st.	Stone.
cov.	Covered.	L. H.	Lighthouse.	str.	Stream.
Cr.	Creek.	Long.	Longitude.	T. G.	Tollgate.
cul.	Culvert.	Mt.	Mountain.	Tres.	Trestle.
d.	Deep.	Mts.	Mountains.	tr.	Truss.
D. S.	Drug Store.	N.	North.	W. T.	Water Tank.
E.	East.	n. f.	Not fordable.	W. W.	Water Works.
Est.	Estuary.	P.	Pier.	W.	West.
f.	Fordable.	pk.	Plank	w.	Wood.
Ft.	Fort.	P. O.	Post-office.	wd.	Wide.

Stride Scales

In making sketches the most convenient method of measuring distance is the stride (2 paces). It is necessary then to know the average length of your stride.

A course is laid off, let us say 500 meters long, running up and down hill. Walk this course forward and backward several times, counting the number of strides taken. Suppose the number to be 320 strides. The problem is now to determine the length in centimeters of the stride. Divide the length of the course in meters by the number of strides taken to cover it, and multiply the result by 100. That is, 500 divided by 320 × 100 equals 156 plus centimeters. That is the length of the sketcher's stride in this particular case.

We now wish to construct a scale by which the sketcher will be enabled to measure off 1000 of his strides on a map of 1/5000. In taking 1000 strides the sketcher will traverse on the ground 1000 times 157 centimeters or 1570 meters. This distance on the map of 1 over 5000 will be 1/5000 of the actual distance on the ground or 1570/5000 meters or .314 meters or 31.4 centimeters on the map. That is, your working scale of 1000 strides will be 31.4 centimeters long.

Some difficulty will be encountered in dividing 31.4 cm. into ten

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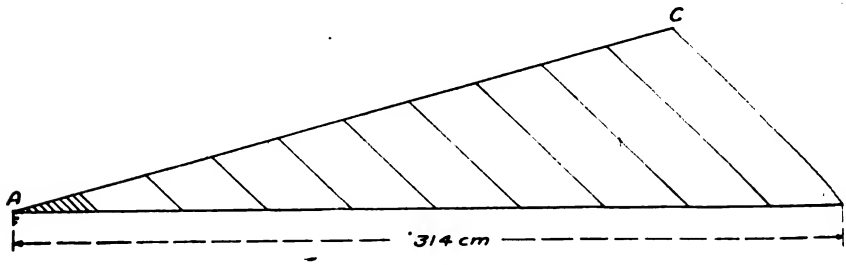
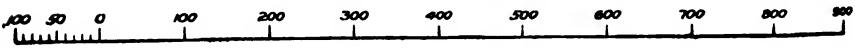
parts. It may be accomplished easily as follows: Lay off a line AB 31.4 cm. long. From A draw a line of indefinite length at any convenient angle with AB. Lay off on this line, AC, ten equal distances, using any convenient unit. The width of a thumb-nail, or any other arbitrary unit, will do. Join the last one of these points with B. By means of a triangle and ruler draw lines parallel with CB from each of the points on the line AC. These lines will cut AB into ten equal parts. One of these divisions should be further subdivided into ten parts, each division representing ten strides.



The scale should be numbered as in sketch below:



Exercises

How long will 1000 strides be on a map of 1/10,000 if the sketcher traverses a course 914 m. long and takes 540 strides?

Answer: 16.9 cm.

If the scale is 1/5000? 1/20,000?

Answer: 33.8 cm.: 8.45 cm.

Contours

Military maps must have some means of showing hills and valleys and the officer must be able from these maps to form a mental image of the country represented. "To the beginner every hill is an isolated feature—the elevations and depressions of the ground present to him nothing but irregularity and confusion."

Most present-day ground forms have a good deal of regularity. They are the result of erosion. Water has carved out the land to make valleys and has enlarged small depressions into canyons. The drainage system of an area therefore made the area what it is. An understanding of the drainage system will give an understanding of the topography of the entire area.

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These ground forms made by running water are generally shown on military maps by means of contours. A common definition of contour is "a line joining points of equal elevation." The foregoing is a true statement but it is not a precise statement. A contour line is a line each point of which has the same elevation. The two definitions are fundamentally different.

If one walks along a contour line one neither goes up hill or down hill but remains always on a level. The surface of a quiet pond which has no outlet is practically level. Therefore its shore line is a contour line. If one follows it in the direction of the hands of a clock, he will find that he must turn to the left at every entering valley, walk up the valley until he heads the water line, cross the valley, then turn again to the right, following down the other side of the valley to get around the point of the hill or spur which lies between it and the next valley. His course will bend to the left at every little inflowing drainage line, cross it, and turn again on the other side to avoid leaving the level. We see then that valley contours apparently go in pairs, that is, there is always one of the same elevation on each side of the valley. They form a sort of a V which opens out in the direction water flows; point of the V upstream. Similarly the spur contours apparently go in pairs. They form a sort of U which opens out to the higher ground of the spur. (In glacial country the valleys are more nearly U-shaped and the ridges sharp.)

The typical contour, then, is the curving line, alternately salient and reëntrant, a series of rude V's for the valleys and U's for the spurs, the point of the V at the stream crossing, the curve of the U at the ridge crossing. If the extreme points of the V's and the U's are determined and these points are connected by curving line, opening out gradually as we go downstream from the points of the V and rounding out to the curve of the U, we get a line which will roughly represent the contour of the ground for that elevation. In other words, the points of the V's, or the points where the contours cross the stream, and the points of the U's, or the points where the contours cross the line of the watershed between two valleys, are essential control points for the drawing of any contour lines.

The single contour which marked the shore lines of the pond will, of course, give no indication of the shape of the hills which surround the pond. To indicate these ground forms, we must have a number of contours each one of which shows the path which a man would follow if he walked around the hill forms on a level line. These level lines should be spaced at equal intervals in a vertical direction. In

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other words, if we take the shore-line contour as the datum contour, the next line should show the path which a man would follow if walking on a level line, say 5 m. higher than the pond, and the next, 10 m. higher, etc. This 5 m. vertical interval between the level lines is called the **contour interval** or the **vertical interval.** It may be one, five, ten, or one hundred meters, or any other number of meters.

Critical Points

It is manifestly impracticable in mapping to locate, with instruments in the field, the points where each contour crosses each drainage line, nor is this necessary. No map can show every change of

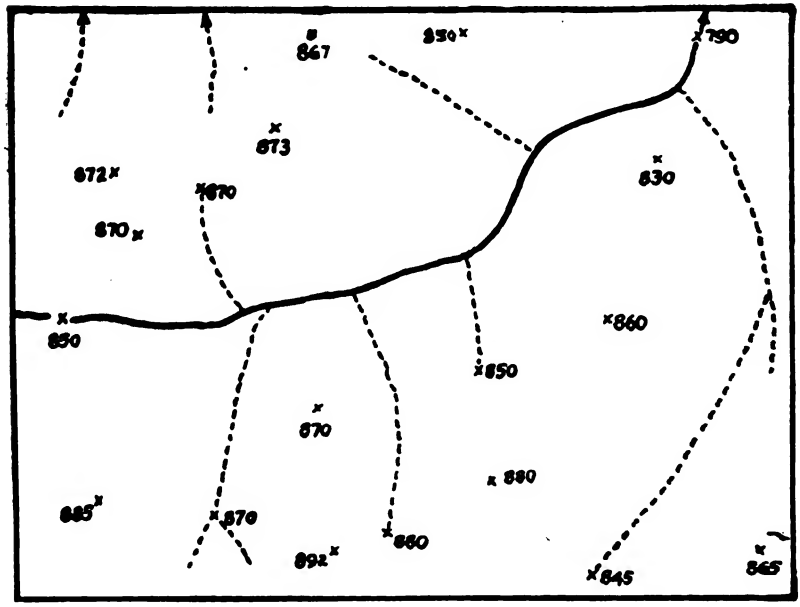

Fig. 1

form of the ground. We must satisfy ourselves, therefore, with locating the critical points of the master lines of the ground. Such points are the heads, changes in direction, and the changes in slope of the drainage lines; the tops, the changes in direction, and the changes in slope of the ridge lines. It will also be impracticable to determine the elevation of the head of every little gully or the location and elevation of every change in direction of every drainage line or of every ridge line. But we must locate the master critical points of the master ridge and stream lines, and the elevation of these points must be determined as well as the location of them. J+

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is very important, however, to plat in every gully, though the elevation of its head be not determined, as these small drainage lines affect the shapes of the hill forms very decidedly and, furthermore, they are landmarks of great value. When the critical points and the drainage net have been located as above described, one who knows something of the laws of nature, and remembers what a contour is, can interpolate between the master critical points enough of the others to enable him to draw all of the contours.

Interpolation

Figure 1 is a skeleton sketch, giving the complete **drainage** net and a few of the **master critical points** of a section. The main stream

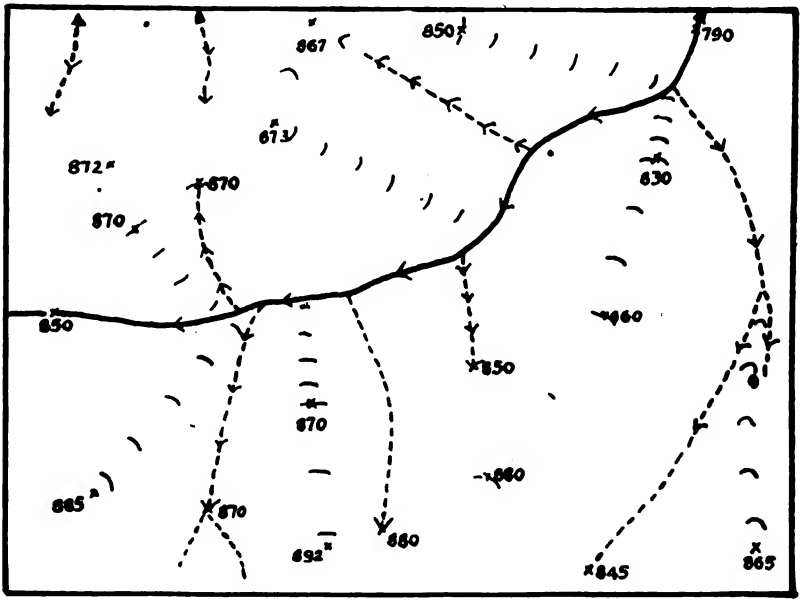

Fig. 2

line of the area is shown as a solid line. The direction of flow is indicated by the arrow near elevation 790 (upper right-hand corner). The elevations of two points on the main stream are given (790 and 850). Smaller tributary drainage lines are indicated in dashed line. Elevations not on stream lines are **critical points** on the ridge lines.

The problem is to draw logical contours at 10-meter vertical intervals, with no other data than that given. The **first step** is to locate the points where desired contours cross the main stream line. As there are no falls between elevation 790 and elevation 850, it is

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assumed that the slope of the stream between these points is **nearly uniform,** becoming, however, a little **steeper** as the stream is **ascended.** Under this assumption the crossing points of contours 800, 810, 820, 830, and 840 are at once interpolated by eye on the main stream between 790 and 850. By interpolation between these, the elevations of the points where each of the tributary ravines enter the main stream are secured. Between **these latter points** and the **heads of the ravines,** the elevations of which are given, the points where the contours cross each of the ravines are marked.

Each point shown along the **ridge lines** was chosen as being a

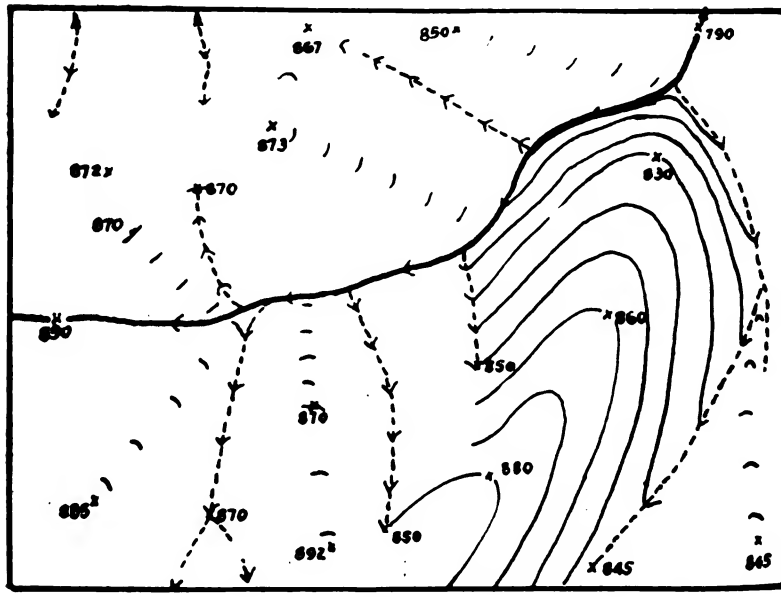

Fig. 3

critical point, that is, a point where the slope or direction of the ridge changes. From point to point along the ridge lines, it is assumed that the slope is uniform. The points where the intervening contours cross the ridge lines have, therefore, been interpolated. The result of interpolation along stream and ridge lines is shown in Figure 3. As a rule the ridges and spurs of eroded hills point in the general direction of the junctions of the streams which have eroded them. Therefore, interpolations have been made in these directions.

Drawing the Contours

In sketching in open country, where all the features can be plainly seen, the method of drawing in the contours from this con-

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trol is to **revisit** the **predetermined critical points** and to draw in all the contours which are needed to represent **one feature,** that is, one **spur** or **hill** at a time, using the drainage lines as the limits of the unit **feature** to be drawn. The smaller irregularities of the ground are brought out by slight changes in contour spacing and contour direction, here and there. Figure 4 is the completed sketch. It is very good representation of the ground.

Characteristics of Contours

1. All points on any one **contour** have the **same elevation. It is a level line.**

2. **Every contour closes** on itself, either within or beyond the

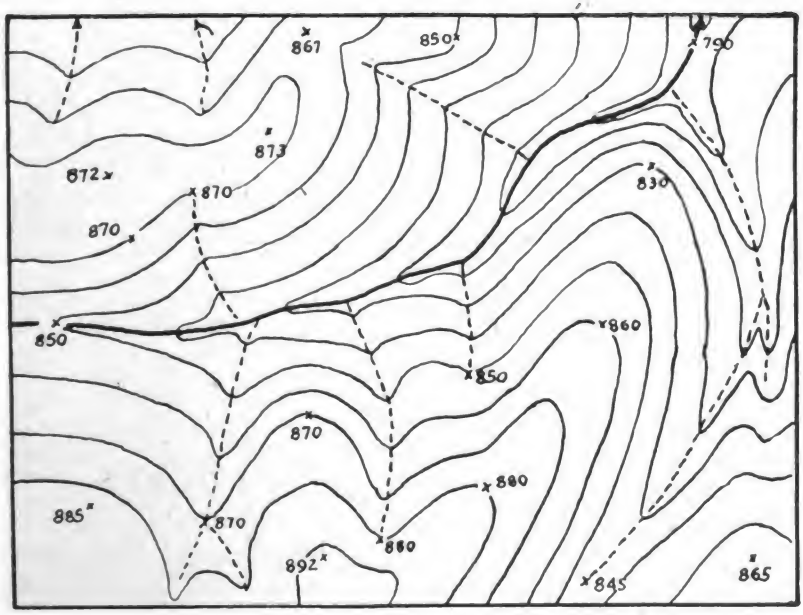

Fig. 4

limits of the map. In the latter case the ends of the contour line **will run to the edge of the map.**

3. A contour which closes within the limits of the map indicates either a **summit** or a **depression.** In a depression there will usually be found a pond or a lake. If there is no water, the depression must be indicated in some way to differentiate it from a summit. A usual method is to **hachure the inner** side of the **depression contour.**

4. **Contours never** split and never cross each other except in

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the case of an **overhanging cliff,** in which case there must be **two distinct intersections.** These cases are not common.

5. Contours are spaced equally to represent a **uniform slope.** If the slope is a **plane surface** (*i. e.*, if it has no irregularities due to erosion or other cause) the contours are **parallel and straight.**

6. In **crossing a valley** the **contours** run up the valley on one side, turning at the stream, run back on the other side. In crossing a ridge the contours run to the ridge line and, turning, run back on the other side of the ridge.

7. **Contours** are always at **right angles** to the **lines** of steepest slope. They, therefore, **cross the stream lines** and the **ridge lines at right angles.**

8. The **contours** are **farther apart** at the **top** and **bottom** of **an eroded hill** than near the middle, because in these portions the slope is somewhat flatter.

9. **Contours** are usually **closer together** near the **sources of streams**—as a stream is usually steeper near its source. This is not always so. A stream may have at its source a very flat collecting basin, a lake or pond.

10. The **larger** the **stream,** the **flatter** the **slope** in the usual case. Hence, contours are usually closer together on tributaries than on main streams.

11. Bad shaping of contours is usually due to illogical interpolation between critical points. Remember that the **drainage lines** and **ridge lines** are **master lines** of your contours. Interpolate along **drainage lines first,** beginning on the main **lines** and going to the tributaries. Then search out your **ridge lines** and **interpolate** along the **lines of the ridges.**

12. If one has difficulty in tracing out a particular contour, he may be helped by imagining himself to be walking along the contour. If he starts out with **low land** on his **right hand,** he will always have **low land** on his **right hand** as long as he walks that contour in that direction and vice versa.

Visibility

Contoured maps not only give a general idea of the lay of the land but they afford a basis for comparison of the elevations of various points. This is important to the artilleryman in two ways. First, it enables him to read from the map the angle of site between gun positions and targets. Second, it enables him to know exactly what he or an enemy should be able to see from a given point. Thus

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routes to and from positions may be chosen entirely from the map in such a way that enemy observation is impossible. There are two simple methods of determining visibility. The simplest is the graphic or profile method. It consists of constructing on gridded paper an exaggerated profile of the ground in the plane of vision of the observer. The exaggeration is proportional. The profile may

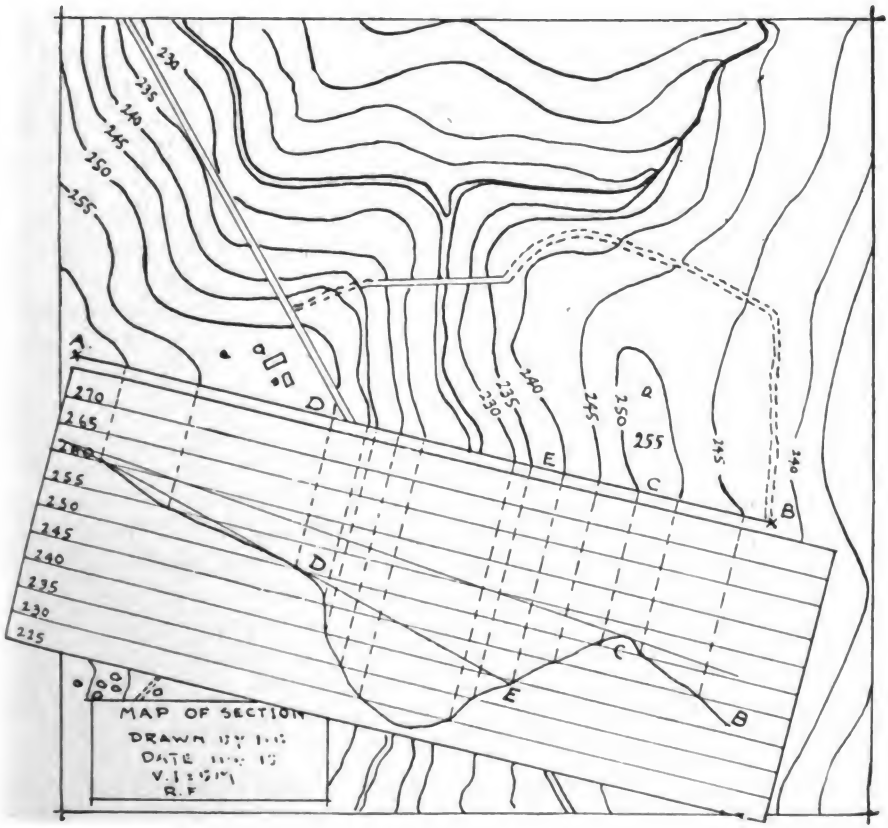

Fig. 5

be accomplished as follows: Draw a line from the point on the map which represents your observation station to the point representing the target or the area which you desire to take under observation. Take your gridded paper (or any ruled paper), number the horizontal lines with the elevations of the ground as shown by contours, beginning near the top of the sheet with the highest elevation and numbering downward to include the lowest elevation represented by contours on the line you have drawn. Lay the gridded paper on the map so that the top of the paper is close to the line and

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parallel with it. Draw a line perpendicular to AB from the point A until it reaches the horizontal line on the gridded paper representing the elevation of the point A on the map. Thus, if A have an elevation of 265 meters, the line will be projected to the horizontal grid line number 265. Project each contour line similarly to the gridded paper. Join the ends of these lines. The result will be a curve as in the diagram. Now draw a line on the gridded paper from the point A and tangent to the point C. That is your line of vision. It is clear that B may not be seen from A because Hill C is in the way. By drawing a line from A tangent to D it will be seen that the river valley shown in the map is invisible from A. To solve the original problem it would not be necessary to complete all these operations. A brief inspection of the map would enable you to omit plotting all points except A, C, and B, because C is the only high ground between A and B. It is the only thing, in other words, which can come in your line of vision. Constructing the whole profile, however, has the advantage of giving additional information. It is clear from the diagram, for example, that the river valley between the points D and E cannot be seen from your observation station.

This same problem may be solved in another way, viz.: by proportion. It is 7000 meters from A to B and 6000 meters from A to the crest which we will call C. The problem is to discover whether C is the line of vision between A and B. The elevation of A is 260 meters, of B 245 meters, of C 255 meters. Let X equal the height above B of the line of vision from A as it passes over crest C. Fig. 6.

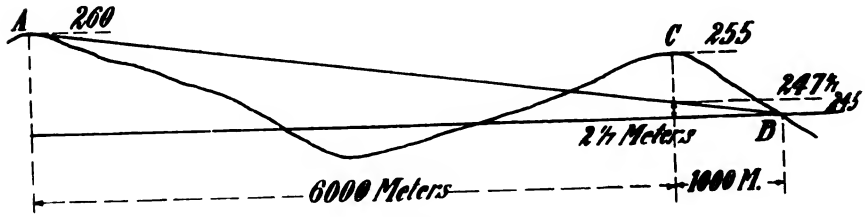

Fig. 6

By similar triangles, then, X is to 15 (the height of A above B) as 1000 is to 7000 or $\frac{X}{15} = \frac{1000}{7000}$ or $X = \frac{15}{7}$ m. or 2 1/7 m.

That is, in looking from A toward B the line of vision would pass 245 meters plus 2 1/7 meters equals 247 1/7 meters above the datum plane at a point 6000 yds. from A. But the crest C is 255 meters high. Therefore B cannot be seen from A. This same method may be applied to any visibility problem. Like the profile method it does not account for trees which may further obstruct vision.

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Construction and Use of the Slope Scale

If on a horizontal line A—B 57.3 inches, long, we erect a perpendicular line B—C, 1 inch long, and connect C with A, we have constructed an angle of 1 degree.

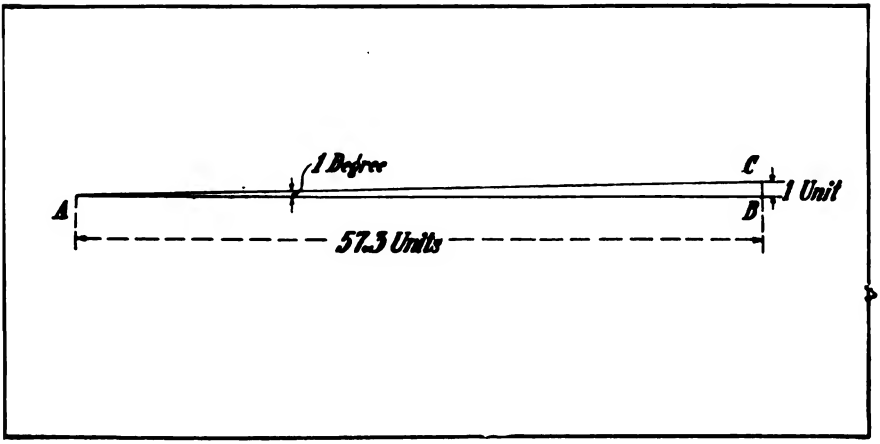

FIG. 7

Similarly if in 57.3 meters the ground rises 1 meter, the slope of the ground is 1 degree.

(a) We wish to devise a slope scale graduated in degrees in constructing a sketch the representative fraction of which is one over 10,000 and the vertical interval 5 meters.

For a slope of 1 degree we would have a horizontal base of 5 times 57.3 meters, or 286.5 meters on the ground. Since the representative fraction is 1 over 10,000, this distance will be represented by a line 1 ten thousandth of 286.5 meters, or 2.86 cm. This will be the distance apart of adjacent contours for a slope of 1 degree on a sketch with the given representative fraction and vertical interval.

From similar triangles it will be seen that for a slope of 2 degrees the adjacent contours will be one half this distance apart, or 1.43 cm.; for a slope of 3 degrees, one third this distance, or .95 cm., etc.

By laying off a line of any convenient length and graduating it in units of 2.86 cm., we can construct a scale for use with slopes of 1 degree, and by interpolating graduations between these lines we can construct scales for any desired degree of slope.

(b) Suppose our problem is to construct a slope scale for a sketch with a representative fraction of 1 over 20,000 and vertical interval of 5 meters.

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As before, the base for a rise of 5 meters will be 286.5 meters, and this distance will be represented on our sketch by one twenty-thousandth of 286.5 meters, or 1.43 cm. This will be the distance apart of adjacent contours for a slope of 1 degree.

(c) Let us suppose our problem had been to construct a slope scale for our sketch with a representative fraction of 1 over 20,000, the vertical interval, however, being 10 meters instead of 5.

The distance apart of contours will now be 10 times 57.3 divided by 20,000, or 2.86 cm. which is the same as example (a) above.

Thus it is seen that a slope scale constructed for use with a sketch whose representative fraction is 1 over 10,000, V. I. 5 meters, may be used for a sketch whose R. F. is 1 over 20,000, V. I. 10 meters or a sketch whose R. F. is 1 over 5000, V. I. 2½ meters, or for any sketch whose representative fraction and vertical interval are in this proportion.

A Simple Traverse

The first traverse should be small, not more than 200 M to a side, and be five sided. The five points marking the traverse will be conspicuous and easily identified. It must be a closed traverse, *i. e.*, the student must be required to traverse completely around the area. Some conspicuous object within the area or only a short distance outside of it should be assigned for location by intersection. It should be near at hand so that its location may be verified by traverse. Station No. 4 may be chosen as this point if convenient.

Precautions: (a) Use a hard pencil, sharpened to a fine point. Even on maps of large scale a wide pencil line will represent the width of a road. A soft pencil will smudge and confuse the map.

(b) When drawing a line with a pencil always hold it vertically or nearly so, and make certain that the lead is kept in contact with the edge of the ruler. The most common fault in drawing lines is to begin with the pencil at slant, the wood of the pencil holding the lead away from the ruler. As the line is drawn the pencil is held in a more and more upright position, causing the lead to come nearer and nearer the edge of the ruler. The line drawn is, of course, not parallel to the edge of the ruler.

(c) Always sight along the same side of the alidade. The three sides may not be precisely parallel. If this suggestion is followed the error will be constant in the work and will make no difference.

(d) In setting up the drawing board, make sure that it is level or approximately so.

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Procedure: (a) Stick the pin in the paper at the point where you assume yourself to be. We call this station Number 1.

(b) Lay your alidade on the board and, rotating it about the pin, sight on the next point of the traverse which we will call station Number 2. Draw a line along the alidade on the side nearest the pin.

(c) Pick up the outfit and walk from station Number 1 to station Number 2, counting the number of strides.

(d) Lay off along this line from your stride scale a distance representing the number of strides you have taken. Put a dot at this point, and stick the pin in it. It is station Number 2.

(e) Set up the board.

(f) Lay alidade along the line 1–2 and rotate the board until the alidade sights on station Number 1. The board is then oriented by back sight.

(g) Without moving the board, rotate the alidade about the pin at point Number 2 until it sights on station Number 3 and draw a line as in (b). You have thus constructed an angle which is equal to the actual angle 1–2–3 on the ground.

Continue this process around the whole area.

Be particularly careful actually to complete the last leg of the traverse. There is a tendency to complete the traverse by joining No. 1 and No. 5 without orientation or measurement.

The use of a compass during preliminary work with a plane table is frequently confusing. A compass is not necessary in running any kind of traverse. The magnetic arrow will be drawn on the sketch when the section has reached its No. 1 station the second time. The arrow is merely for convenience of future readers of the map or sketch.

Traverses may be divided into two general classes: closed traverses and unclosed traverses. A closed traverse is one which has as its origin a known point and which closes or ends at the same or another known point. An unclosed traverse has as its origin a known point but ends at a point not previously determined.

It is rarely possible with sketching equipment to close correctly a traverse upon a known point. There is almost always a considerable error, and some method of adjustment must be used. If the next to the last station in the traverse were simply joined by a line to the closing point, all the error of the traverse both in direction and distance would be concentrated in the one line and angle nearest the point of closure. The error would be misleading to anyone attempting to use the sketch. It is better to distribute this error throughout the whole traverse, thereby making the errors both in direction and distance a minimum.

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In Figure 8 we have a closed traverse of five stations. The error of closure is represented by the distance 5–0. To close the traverse each point of the traverse (1–2–3–4–5) is moved IN THE SAME DIRECTION in which point 5 must be moved to coincide with point zero. Point 1 being moved 1/5 of the distance, point 2, 2/5 of the distance, point 3, 3/5 of the distance, etc.

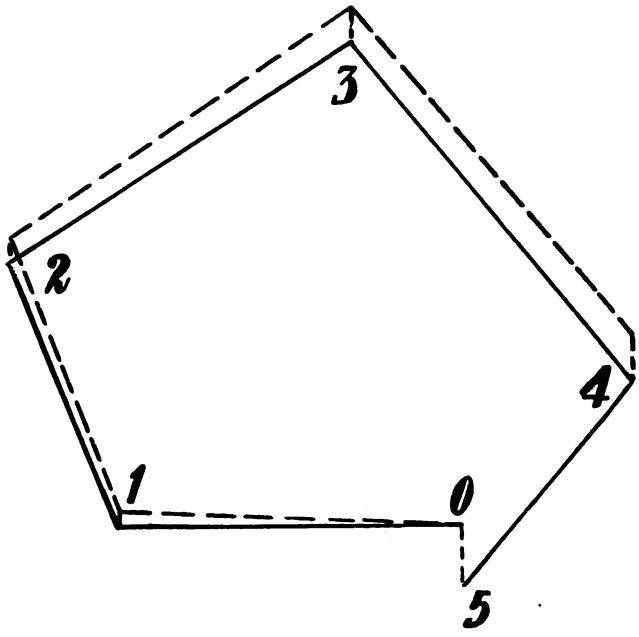

FIG. 8

The first step is to divide the distance 5–0 into five parts (or the number of the stations in the traverse). From each of the stations in the traverse draw a line parallel to the dotted line 5–0 and in the direction in which point 5 must be moved to make it coincide with point zero. Lay off distance from point 1 along this line equal to 1/5 of the distance 5–0 and mark the point. Lay off a distance from point 2 along this line a distance equal to 2/5 of the distance 5–0. Repeat this for each of the points in the traverse. Join these new points by lines and the traverse is adjusted.

The permissible error of closure in traversing with sketching instruments is about 5 per cent. of the total distance traversed. If the error is greater the traverse should be repeated because in all probability a gross error has been made at some one point.

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Orienting the Map

Definition: A map or sketch is said to be oriented when a line on the map is parallel to the line it represents on the ground and is in a corresponding direction.

A map provides a means of finding the way from one point to another point or of showing someone else how to do so. In order to accomplish this, it is first necessary to know the direction on the ground with the relation to the map and, next, one's approximate location on the map. This process is called Orientation.

The map may be orientated: (1) By back sight or modifications of this method; (2) by compass. Both of these methods will result in placing lines on the map parallel they represent on the ground. If a roadway shown on the map can be identified with a road which can be seen on the ground it is simple to rotate the map until the two roads are parallel. Every other road shown on the map will be parallel to the roads which they represent on the ground if the map is accurate. If you are able to determine your exact location on the map and on the ground, it is generally possible to determine direction by inspection. The process is this: Identify some other point both on the ground and on the map. Rotate the map until the line between you and the point you have identified on the ground coincides in direction with a line joining these two points on the map.

The second means of orientation is by compass. North is shown on almost every map by an arrow, magnetic north usually by a half arrow. By placing the map on the ground and rotating it until the magnetic arrow corresponds in direction to the needle of a compass placed upon it, the map may be roughly oriented. Several factors make this orientation only approximate. The needle of a compass does not point precisely in the same direction each day in the year or each hour in the day. This phenomenon is called magnetic variation. A more important factor is called local attraction. When a compass is near large bodies of metal, it points toward the metal. High-power electric lines tend to make the compass turn at right angles to them. Unless a compass is used with the greatest care the results may be misleading.

Even in the maps made by our geological survey it is impossible to measure the distance between every crossroad and every hilltop. To make a fairly accurate map without doing this, a point of beginning is arbitrarily chosen. Its position geographically is determined with maximum precision by astronomical readings. From that point a base line is measured with maximum accuracy. The

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base line is perhaps twenty miles long. In the measurement, correction is made even for the expansion and contraction of the steel tape due to variations in temperature. The direction of this base line is determined with maximum accuracy.

The accuracy of these initial measurements is about one in a million. That is, in measuring one million feet the maximum error would be only one foot. Or in measuring a thousand yards the allowable error would be one thousandth of a yard.

From the ends of this base line the angular reading to some point is taken with similar accuracy. A triangle is thus formed. The length of these two sides is computed by trigonometry. From the point thus determined and the two initial points more angular readings are taken, thus building two more triangles on the first. No more base measurements are necessary.

Another base line is, however, laid off at some distant place and another party of surveyors set to work on exactly the same process. These two parties will eventually run into each other. Their work serves as a check on accuracy.

The points located in this survey are called points of the first order. They are very accurate. Within each of these triangles, however, a set of smaller triangles is built up. The points thus determined are somewhat less accurately located. Within these second triangles still another set of triangles are made and points are located somewhat less accurately.

The points of the second order are not more than half a meter out of the way. Points of the third order are within two meters of perfect accuracy.

This whole system of triangles is called the triangulation net. The points they have located and marked on the map are called triangulation points or geodetic points or control points. These points are marked with a certain conventional sign on the French maps.

In the topographical work the artilleryman can do in the field, these precise methods are not possible because of the nature of the instruments available and the speed with which the work must be done. Among the instruments used by artillerymen are a plane table or drawing board mounted on a tripod, an alidade, a clinometer or a locator's level, a pace tally, and a holder for a timing pad (for mounted sketching).

The plane table is a board about sixteen inches square or larger, with clips for holding drawing paper. Sometimes thumb tacks are used. A compass is sometimes set into one edge of the board. On the back of the board is usually a slope-measuring device. It is

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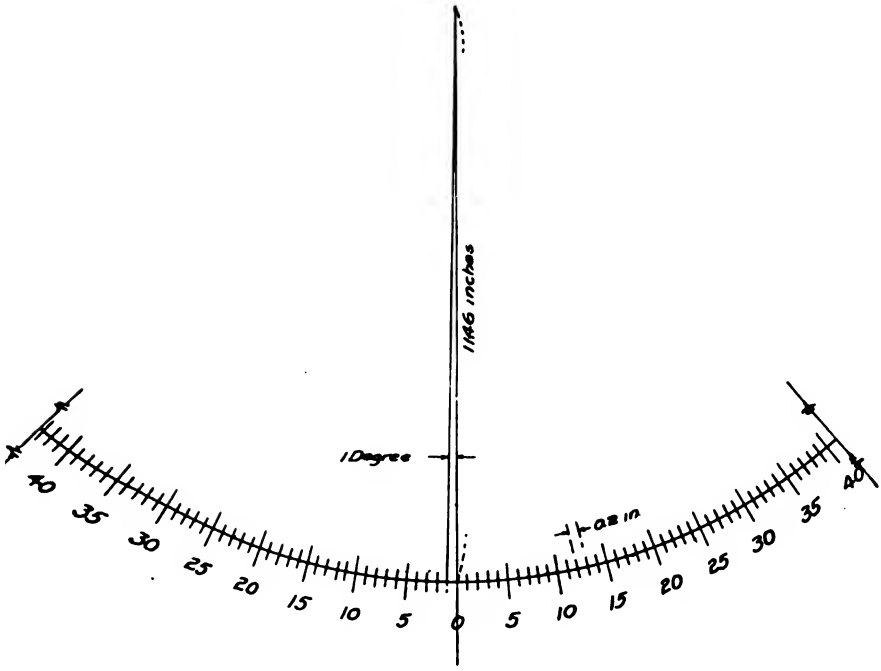
constructed as follows: If you advance 57.3 units up a slope of 1 degree you will be 1 unit higher than when you started. It makes no difference whether the unit is yards, or meters, or inches. If you advance twice as far on a 1-degree slope you will be two units higher than at the point of starting. Thus, if you draw an arc on the drawing board with the radius of 11.46 inches and divide the arc into segments .2 of an inch long, each segment will represent 1 degree.



Or with a radius of 5 × 5.73 cm. = 28.65 cm. the subdivision of arc, will be 5 × 1 mm. = ½ cm. for 1°. slope. It is frequently more convenient to measure slopes in mils. Lay off an arc with a radius of 30 cm. Lay off on this arc divisions of 3 mm. Each division will represent 10 mils.

A hole is bored in the drawing board at the center of this uncompleted circle, and a string about 18 inches long passed through the hole and knotted. A weight is attached to the other end of this string.

Diagram of Man Using the Slope Board

The alidade is used for three purposes: (1) as a sighting vane; (2) as a ruler; (3) and for measuring degrees of slope on the map.

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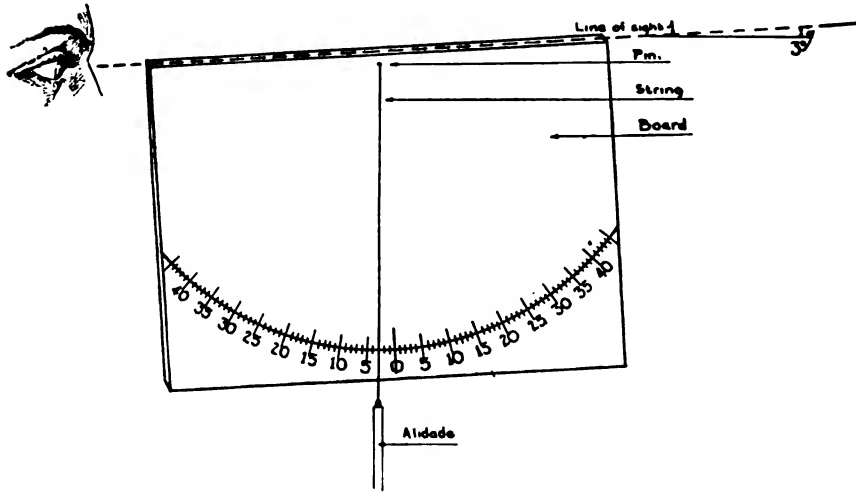
This last function of the alidade is explained later in the course. There are three kinds of alidades which you will see in the artillery: the first is a simple triangular ruler, the top edge of which is used as a sighting vane. The second kind is a boxwood ruler with folding leaf sights. The third is a leveling alidade—a brass ruler with a level bubble insert and two brass folding leaf sights. The sights are graduated usually in mils so that the elevations may be read. A more elaborate alidade is the telescopic alidade.

There are two kinds of clinometer in more or less general use in the service. The more recent type measures in mils and is used to obtain elevations. It is used thus: sight through the tube with the



horizontal crosshair of the objective on the point the elevation of which it is desired to know. Rotate the rocker without moving the tube until the level bubble appears to be centered in the mirror on the right-hand side of the sighting tube. Read the vertical angle down to 10 mils on the vernier. The old service clinometer reads in degrees, and is less accurate. A locator's level used for the same purpose also reads in degrees.

The pace tally is simply a convenient means of counting strides.

Panoramic Sketching

The Panoramic Sketch having become increasingly important in the military service, it is essential that there be uniformity in the methods of making it, so that it may convey the military information desired in the clearest and simplest manner, omitting all other

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information. The fundamental principles applicable to a good sketch are—clearness to the point of bareness, a definite horizontal SCALE, a means of orientation, and a knowledge on the part of the sketcher of what details to omit AND THEIR OMISSION. Just as a military map differs from other maps, so does a military panoramic sketch differ from a landscape,—it should be simply a chart of military information, drawn as nearly like the country it represents as the individual skill of the sketcher allows. It is a fallacy to assume that a high degree of artistic ability is necessary; for, with a knowledge of a few elementary principles and a definite system of procedure, anyone can quickly make a valuable and accurate sketch.

The immense value of the panoramic sketch lies in the fact that it presents terrain pictorially, and from a viewpoint to which we are accustomed, so that the story it tells is self-evident at a glance and long explanation is eliminated. Hence it should be made an accurate picture of the country desired, stripped of everything but essential military information, and drawn to a scale by which the relative location of natural and artificial features from a definite origin can be measured.

The inexperienced sketcher examining a landscape is confused by the mass of detail that meets his eye. Important and unimportant features are so numerous and mixed together that it seems a hopeless task to pick out and recognize the simple framework on which the whole is built. It is necessary, therefore, that the eye be trained to separate a landscape into its main mass groups, disregarding details, and bounding these masses by single lines so that the relative position and size of these masses, both vertically and horizontally, shall form the framework of the whole. The lines bounding hills, mountains, crests, and tree groups and their intersections with each other form such mass groups, and once having recognized these main boundary lines, and having plotted them in their relative horizontal and vertical relation, our framework is complete and important details can then be quickly inserted in their correct position. A simple method of recognizing these mass groups is to half close the eyes and examine the country, when these groups will become immediately apparent.

The first step necessary is to determine by actual inspection the limits of the sector. Having located the limits of your sector MEASURE IT with a B. C. ruler, or some other instrument for measuring horizontal angles. Since the panoramic sketch is drawn to a definite horizontal scale it is necessary to determine this scale before proceeding. From an examination of Figure 9 it will be seen that the artillery sketching pad is divided into eight vertical zones be-

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tween the two limiting vertical lines. Hence, if our sector measures 800 mils, the distance between any two adjacent vertical lines, will represent 100 mils; if our sector is 400 mils, the distance between

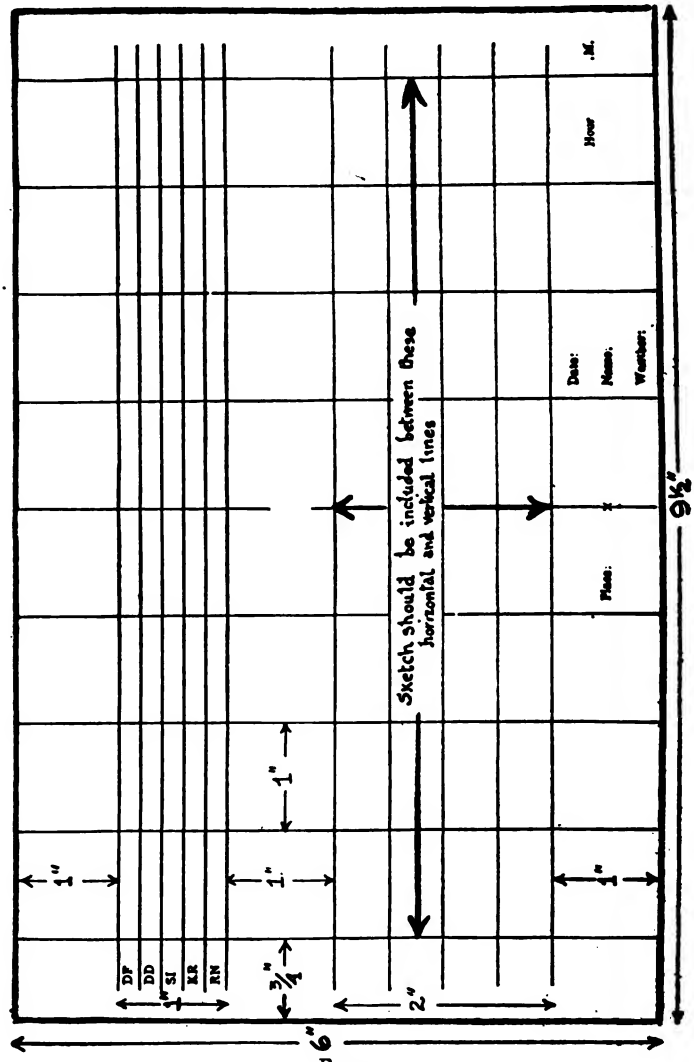

FIG. 9

adjacent vertical lines will represent 50 mils,—etc. For a pad ruled in any similar convenient manner the scale of the sketch can be determined.

It is essential that **identification of the sketcher's position and the orientation of the sketch** be done IMMEDIATELY, for the impor-

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tant reason that unless this information is shown, the sketch is of slight value to anyone else attempting to use it.

At the bottom of the sketching pad and opposite the word "Place" there is a cross mark on the center vertical ruled line. It is through this mark that the arrow indicating the magnetic north is drawn. Its direction is determined in the following manner.

As shown in Figure 9, turn the sketching pad into a horizontal position. Sight along any vertical line at or near the center until this line, if prolonged, passes through the exact point on the landscape through which it will pass in the sketch. The sketch is now oriented.

Holding the pad in this position place a compass on it and allow the needle to come to rest.

Through the cross-mark on the center vertical line draw an arrow parallel to the compass needle. Note, in the spaces indicated, the place from which the sketch is made, the name of the sketcher, date, weather, AS REGARDS VISIBILITY, and the hour of the day.

Before proceeding further, EXAMINE THE SECTOR with and without glasses. The ground should be studied in an effort to get a clear mental picture of its formation and to separate it into its fundamental mass groups. Glasses will often disclose crests, hollows, etc., capable of hiding targets which otherwise might be overlooked. A little study will separate the important from the unimportant details and the sketcher is then ready to proceed along definitely thought-out lines, to conform to the object of the sketch.

In order to make the horizontal scale of practical value an origin of horizontal measurement must be selected from the terrain and then be PLOTTED AND INDICATED on the sketch. A sketch without a clearly indicated reference point is more useless than a map without means of indicating direction. The reference point may or may not be in the sector included by the sketch—it should preferably, if possible, be in the sector but owing to the fact that the reference point must be a distinct, easily identified point, it is possible that a given sector may be devoid of any point that could fulfil these conditions. In this case such a point should be selected as close to either limit of the sector as possible and an arrow should be drawn immediately above the sketch pointing in the direction of this reference point, and should be so labelled. The point selected should further be briefly described as, "Reference point, lone pine tree on sky-line," etc. Under normal conditions a suitable point can be chosen in the sector and indicated directly on the sketch. Since it is the origin of horizontal measurements its angular designation will be zero, a fact which further identifies it.

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In the selection of a reference point, the following considerations should govern: (a) it should be easily seen and identified even under unfavorable conditions of visibility, hence, not too far away (as a distant mountain peak on the horizon). (b) it should be of such a character that it CANNOT BE ENTIRELY DESTROYED BY ARTILLERY FIRE.

Owing to the prevalence of conditions of poor visibility, the most suitable reference points are found in the middle distance, and are preferably features of the terrain, such as,—a small hill of distinctive shape, a well-defined crossroads or road fork, the point where a road crosses a crest, or the intersection of a stream with a road or railroad, etc. These will satisfy all conditions better than houses, towers, chimneys, trees, or distant mountains.

By means of the plotted reference point and the vertical guide lines we have established a basis of horizontal control. By actually measuring with the mil ruler the horizontal deflection of important points from the reference point, we can plot these points horizontally on the sketch from the plotted reference point.

In Figure 10 the farm is 200 mils from the reference point; the intersection of crests A is 110 mils, the peak C is 300 mils, etc.

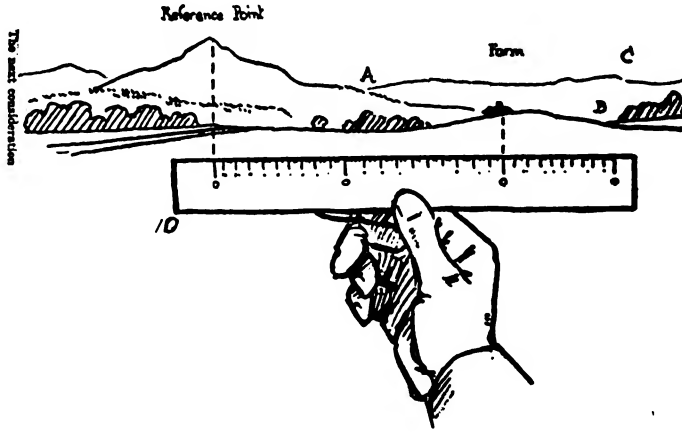

FIG. 10

The next consideration is a basis for vertical control. Since the vertical relation of features of the terrain is of comparatively little importance no attempt should be made to draw it to scale. As long as we show the relative vertical relation, of features approximately, but show their horizontal relation accurately, the sketch is sufficiently accurate for military purposes. In fact a certain amount of vertical exaggeration is allowable for emphasis of important fea-

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tures, but it should never be carried to the point of grotesqueness. Beyond a reasonable limit, exaggeration will give results so far from the actual terrain that identification is impossible.

The sketching in, then, of features in their relative vertical relation is purely a matter of eye on the part of the sketcher. As an aid, however, vertical measurements can be referred to an imaginary horizontal line in the sector which must be established mentally. One of the horizontal lines on the sketching pad which bears the same relation to the sketch as the imaginary line bears to the terrain, can be chosen and relative vertical locations of prominent points can then be plotted with respect to this line.

It will be found that in every landscape features of the terrain form themselves into definite horizontal lines; crest lines, tops of trees, etc., serve to establish these lines. If not, an imaginary horizontal plane at the height of the observer's eye can be projected into the landscape and its imaginary intersection will establish such a horizontal line. From any such line the relative distance of points above and below it can be measured by the eye.

Figure 11 shows an imaginary landscape. The line AB, established by the tops of the trees and the crest of the hill at B, is a horizontal line which will serve as a basis of measurement. The relative distance above and below this line of the points M, L, N, and R can be seen at a glance; and if a horizontal line on the sketching pad has been selected to represent AB, the points M, L, N, and R can be accurately and quickly plotted.

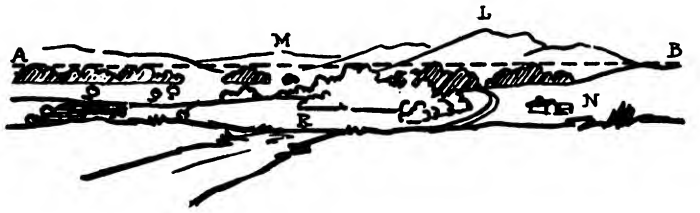

FIG. 11

Holding the sketching pad vertically in front of the eye and looking over the top of the pad at the landscape, by moving the pad to or from the eye a point will be reached at which the two limiting vertical lines of the pad will intersect if prolonged, the corresponding limits of the sector. Figure 12 shows the pad in this position for the landscape.

Holding the pad here draw in lightly in the one inch space at the extreme top of the sheet, the sky line and as many other important points as possible, comparing the outline directly with the country

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as you glance over the top of the pad. This procedure automatically locates the framework horizontally. When completed, lower the pad into a comfortable horizontal position and carry the framework so drawn down into its proper position on the sheet, paying special attention to locating the framework correctly by means of the vertical control. When this is accomplished the work at the top of the sheet may be erased.

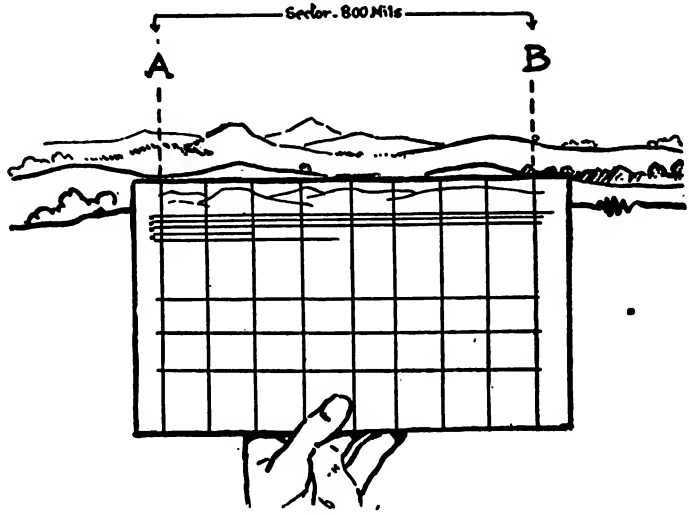

FIG. 12

The framework should be done lightly with a hard pencil, and if time permits it can be gone over later and corrected where necessary. More attention can then be paid to characteristic shapes and formations and to relative vertical relations. The principles of perspective should also be applied.

With the framework established it is a comparatively simple operation to fill in with those details whose importance is governed by the purpose of the sketch. Time being a factor, and the object being to locate targets, the framework is sufficient and no time should be spent on filling in and the framework itself should be only a rough approximation. Hence time and the object sought govern the amount of detail shown and it is here that the knowledge of what to omit makes itself manifest and can only be gained by actual experience.

Speed and simplicity are gained in locating details by plotting limiting points on the framework and then drawing in the details between these points. Points where roads, telegraph lines, fences,

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etc., appear and disappear over crests, horizontal limits of tree groups and settlements, are features that can be located this way. Single points can be located by referring them to points on the sky line under which they are vertically situated.

With the soft pencil go over the sketch and vary the weight of the lines in it, bearing in mind that the weight of line and size of objects decrease uniformly as they recede from the observer, the lightest lines being the objects seen farthest away. Do not waste time on the foreground. A simple heavy line showing its general conformation is sufficient.

In order that the sketch may be of value to others beside the sketcher, points of identification must be designated and their location with respect to the reference point indicated. In the same way, according to the purpose of the sketch, targets, auxiliary targets, points where targets customarily appear, registration points, aiming points, military works, crossroads, houses, towns, etc., are similarly shown.

Figure 13 shows the method of accomplishing this. Vertical lines are drawn from the top of the sheet and terminate in an arrow-

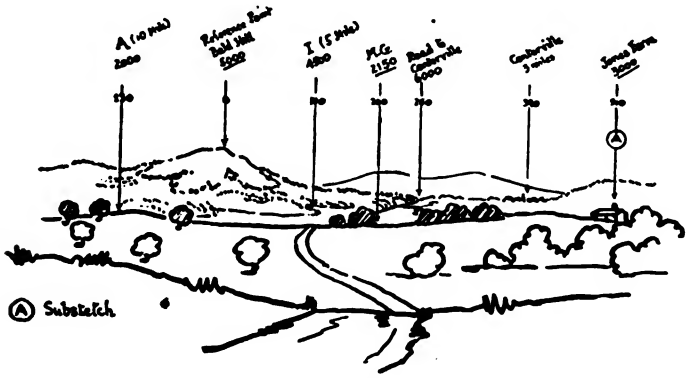

FIG. 13

head at the exact point on the sketch where the point in question is located on the ground. Directly at the top of the line the description of the point so located is written so that it can be read with the sketch held in a normal position. Do not draw in conventional signs for targets. They serve only to add unnecessary detail to the sketch and destroy clearness. Since, in the artillery, the right of the target is the point on which firing data are computed, the vertical line should indicate the location of the right of the target, and if further identification is necessary, its width in mils can be indicated. This would mean then that the arrow-head locates the right of the target and it extends to the left of this point so many mils.

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Simplicity in designation of targets can be accomplished by using definitely understood abbreviations—*e. g.*, I for infantry deployed—A for artillery in position, etc. The reference point should always be indicated as such and may further be given its correct name if known. For quick identification the line to this point may be drawn heavy or doubled. According to the judgment of the sketcher and the purpose of the sketch, any information may be shown, such as names of hills, mountains, farms, villages, destination of roads and railroads, location of bridges, trestles, culverts, etc. The sketcher is governed only by consideration of the relative military importance of the points shown or omitted.

On the artillery sketch, directly under the description of the indicated point or object, should be shown its range. The range is either estimated or measured. If the latter, it is UNDERLINED. By reference to Figure 9 it is seen that at the top of the sheet are five horizontal zones marked at the left DF, DD, SI, KR, and RN. These zones are solely for firing data and these data are filled in before and corrected after firing. The firing data referring to any particular target should be written across the vertical line designating the target, and be in the correct zone.

It is evident, therefore, that a third range occurs. This range, after actual firing and correction, is the gun range to that particular point. Hence on the complete sketch we shall have shown estimated ranges, measured ranges determined by instruments, and gun ranges determined by actual firing.

Immediately below the five horizontal zones for recording firing data (Fig. 9) is a one-inch space before reaching the upper horizontal limit of the sketch proper. This space is used solely for recording ANGULAR DEFLECTIONS. The deflection in mils of the particular point indicated, right or left of the reference point, is placed directly on the vertical reference line. The deflection of the reference point is, of course, zero, which further identifies this point. With a reference point within the sketch, deflections will increase as we move to the right and left of it. With the reference point without the sketch, deflections will increase throughout the sketch as we move to the left or right, depending on where the reference point is—to the right or left of our sector. Deflections are habitually indicated to the nearest multiple of five, as no closer measurement is possible with a mil ruler.

Position or Area Sketching

Always use a sharp pencil.

It is useless to attempt to make an accurate sketch with a pencil which makes a mark as wide as an ordinary country road. Always

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use the same side of your alidade for sighting and the same side next to the pin. This tends to reduce the error if these two edges are not exactly parallel. All the equipment necessary for an accurate sketch is: pin, sharp pencil, alidade with stride scale, and drawing board with paper, the paper fastened on with thumb tacks.

Before starting your sketch look around you at the area to be sketched. Form some estimate as to the size of your finished sketch and begin your sketch at such a point on the paper that you will surely not run off the edge of your sheet. Look for the critical points in the area: high points, ridge lines, and stream lines, and other prominent objects on the terrain. Choose as your point of origin any convenient point near you which can be easily seen and identified from the point on which you make your foresight. Set up your board. Stick in your pin or needle at the point you selected as your present position and with your alidade against your pin sight on your first point in the traverse and draw a line. Leaving the board oriented draw rays toward any point you wish to locate by intersection. It is better to depend mainly upon traverse for location of points than to clutter up your sketch with too many rays.

Now pick up your equipment and traverse to your first point, counting the number of strides. The pace tally is a convenience for this counting. When you have arrived at this point, set up your board and lay off along the ray drawn to this station a distance corresponding to the number of strides taken and stick in your pin. This locates your new position. Next orient your board by laying your alidade along the ray shot to this position and backsighting on the starting point complete any location by intersection begun at the origin, checking the orientation each time before drawing the new ray. Rotate the alidade around the pin and sight on the next point on the traverse. Proceed as before.

In selecting points for foresight be sure to select points which can be seen from the next station on the traverse, remembering that they must be used for a backsight as well as a foresight. In traversing be sure to mark any drainage or ridge lines which you cross, by stopping, scaling off the number of strides taken to that point and marking the ridge or drainage lines by a short cross line on your traverse. It is not necessary to traverse entirely around your area. All your work may sometimes be done by traversing a base line and locating the remaining points by intersection.

If you have a point to locate which would involve traversing up or down a steep slope it is much better to locate the point by intersection rather than by traverse as the variation in the length of stride on a steep slope is considerable. A point quite commonly

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overlooked by sketchers is the method of locating themselves on the line between two objects. This can be done easily by setting up the board, orienting by sighting on one of the points, then backsighting on the other points without disturbing the alidade. Move the board at right angles to the line of traverse until the alidade will sight on both objects. You are now on the line of traverse. Points off the line of traverse such as a winding road, may be located by short cross traverses.

Form the habit of performing the operations of sketching in some regular sequence such as the order outlined above. Do everything possible to save time. Do not orient your board unless it is necessary. For instance do not orient your board until you have stuck in your pin and located your new position. Omit all buildings except the most prominent ones. If necessary they can be sketched in quite accurately later without traverse or intersection. The main features to look out for are the ground forms and natural objects, items of military value such as roads, telephone and telegraph lines, railroads, cuts and fills, etc.

The elevations of the points on the traverse can be determined as you traverse by taking the angular elevation or depression of each point from some known point. Remember that it is not necessary to make this determination of elevation continuous as in the case of the traverse. All the elevations may be determined from some point which can be seen from all points of the traverse. If the elevation of some point in the area is known all other elevations may be referred to this datum point. If there is no point of known elevation convenient assume an elevation for some point as a basis for the elevations of your sketch taking a value great enough to avoid negative signs.

Outpost Sketching

It is possible to make a fairly accurate map of enemy territory without crossing the front line. It is, as its name implies, made by traversing from outpost to outpost taking sights at prominent points in enemy territory.

The traverse should cover the immediate front, stations being situated, if possible, so as to command the territory to be sketched. Having selected the first station, set up the board and place a pin in that corner of your paper from which the sketch can be best constructed. The pin will represent the first station, sight on the second station and draw a ray. With the board thus oriented and particular care being taken to keep it in the same position, draw rays to all prominent points in the area to be sketched. Do not fail to take

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a sight upon some point because it is not visible from the second station, as it may be visible from some later station. Having drawn rays to all prominent points read the elevation of these points by means of the slope scale, writing this information along the ray to that point.

Accurately pace the distance to the second station laying it off on the ray already drawn. The second station now being determined on your map place the pin at that point and orient the board by backsighting to the first station. Proceed as at station number 1, taking particular care to draw rays to all old points visible as well as to all new ones that may have appeared. The intersection of these rays will determine the location of the point, although a ray from another station will locate the point more accurately. Readings on the slope board should also be taken to all points. Continue this process until the traverse is complete, great care being taken to pick out every new point visible at each station. A point having been once accurately determined by sights from three stations it is needless to cover the map with rays by taking further sights to it. A point having been determined the range and altitude may be figured by means of the scales on the alidade.

Place Sketch

Unlike the outpost sketch the place sketch is drawn from one position. The board should be firmly locked in position and with a pin set up as a station draw rays to all prominent points. The distance to these points will have to be estimated and set off on the rays by means of the scale on the alidade. By means of the slope board their altitude may be determined, its accuracy depending upon the correctness with which the range has been estimated.

Road Sketch

A road sketch is usually drawn by advance agents in order to inform the Commanding Officer of the roads and through what sort of territory he and his troops will have to move. The sketch must be drawn very rapidly, only prominent details of military importance or assistance in location being shown. A sketcher proceeds much in the same manner as in an area sketch, the traverse being made along the road and except in unusual circumstances only so much of the surrounding country being shown as is visible from the road.

Orientation

Whenever a position is occupied in any relatively stable sector the following documents are prepared:

(a) Map showing hidden and visible areas. This is always prepared before the panoramic sketch is made.

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(b) Panoramic Sketch. This enables the observer to compare immediately and without difficulty features represented on the map with those on the ground.

(c) Map showing the possibilities of battery fire, which is the result of the computation of dead areas.

The value of all of these documents to the battery itself or to the officer conducting fire needs little explanation. It is impossible to reconnoiter the enemy territory in person on the ground. It is possible to reconnoiter it and learn a great deal about it from the map and with the eye as aided by observing instruments.

But it is to the higher artillery authorities that these documents are especially important. If all three batteries of a battalion send a diagram of hidden areas on transparent paper from each of their observation stations, the battalion commander will see that certain ground which cannot be observed from A battery observing station can be seen from the observing station of C battery. Certain important ground will probably be hidden from all observation posts. Perhaps, however, the observation stations of the neighboring battalion can see a part of that ground. The Battalion Commander sends a consolidated sketch on transparent paper showing what each of his observation stations can see to the next higher artillery unit. There is made further consolidation until finally the artillery commander of the sector knows exactly what areas are not visible from any of his observation posts. He can then arrange for the construction of special observation posts or for balloon and aeroplane observation of these areas.

Also if it is necessary to fire at some target with a heavy battery, the artillery commander can inform the battery commander exactly which of the existing observation posts can best be used in adjusting his fire. Any battery which has a mission assigned it which requires a point of observation different from their own observation post, can easily find and use a post which will satisfy the requirements of the assignment.

The map of dead areas is of greatest importance to the staff. It tells the artillery commander exactly what batteries can fire into every area, and just how effective their fire is likely to be with regard to the slope of the ground, etc.

The actual work of making these maps is negligible after practice and much of it is done habitually by the orientation officer.

These maps may be made without going to the sector at all. It is only necessary to have a map of the sector and to know the location of the observation station and of the guns.

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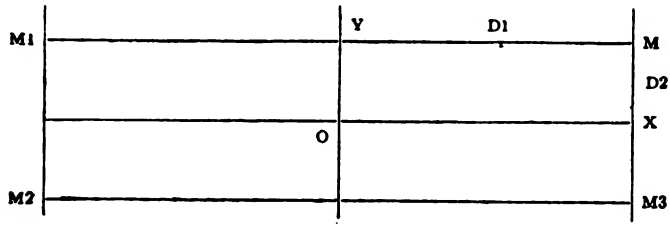
By drawing two straight lines intersecting each other at right angles and designate the North and South line as the "Y" axis and the East and West line as the "X" axis and their intersection as "O" we have a means of designating the location of any point by referring it to these two axes.

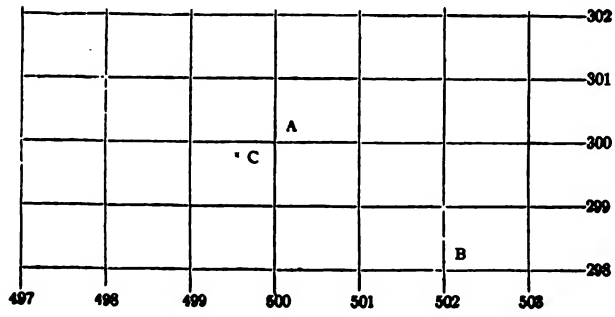


For instance the point M can be indicated by the distance D1 and D2. However, there are four points, M, M1, M2, and M3, which are all at these distances from the two axes. To prevent error it is necessary therefore to indicate the position of the point as follows:

1. Abscissa or X = + D1 if M is to the right or east of OY
2. " " X = — D1 if M is to the left or west of OY
3. Ordinate or Y = + D2 if M is above or to the north of OX
4. " " Y = — D2 if M is below or to the south of OX

This method of designating points is applied to the battle maps of France, by dividing them into a system of squares, called a grid, which are 1000 meters (1 kilometer) on a side and by numbering the lines forming the grid with reference to a central point which in order to eliminate the plus and minus signs is arbitrarily given the value X = 500,000 Y = 300,000. The central point thus designated is the location of the town of Treves in Germany.

Let us assume the grid which would appear on a map of the country surrounding Treves to be as follows:



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The point A will be the location of Treves.

It will be noticed that the east and west grid line through A is numbered 300 and the north and south grid line 500. The successive grid lines are 1000 meters (1 kilometer) apart and the numbers increase as we go north from Treves and decrease as we go south and increase as we go east and decrease as we go west.

Take the point B; its coördinates are X = 502,000, Y = 298,000 and by comparing its coördinates with those of Treves we see that it is 2000 meters east of and 2000 meters south of that point.

Each one of these 1000 meter squares is subdivided into squares of 100 meters, which are resubdivided into squares of 10 meters and the latter can be divided so that the coördinates of a point may be read on the larger scale maps, with considerable accuracy, to the meter.

The point C for instance might be read by use of a scale as X = 499,565, Y = 299,785.

From the above it is evident that to define a point by its full coördinates it is necessary to give twelve figures. This, however, is not usually necessary in actual practice and results in a great saving in time and possibility of errors in transmission by wire, especially from aeroplanes to the ground.

As a general condition the different units which are working together will be using the same battle map as each map on the 1 to 20,000 scale covers the area usually allotted to an army corps, so that it will not be necessary to transmit the first two figures of the coördinates, and since as a general rule the observer cannot locate points or targets closer than 100 meters and the closer designation is not essential to the battery commander, for numerous reasons, it is not necessary to transmit the last two figures.

Objectives are therefore usually designated by what are called their "hectometric coördinates," that is by the units indicating the thousands and hundreds of meters only. The coördinates of the point C above would thus be given as X = 95, Y = 97 and would be actually sent as the number 9597 without any division between the 95 and 97. The receiver of such a designation would, in order to locate the point on his map, first look along the bottom of the map until he found a number of the grid whose last unit was 9 and along the side of the map until he found a grid number whose last unit was 9, then at the intersection of these two lines he would measure half-way to the next vertical line, that is 5 units over and seven-tenths of the way up to the next line above, thus locating the point within approximately 70 meters.

Other systems of coördinates are used with success—notably the English system used during the war.

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Titles

Each sheet has a serial number and a title; the title is the name of the locality which is the most important in its vicinity, usually the largest town or village on the sheet.

Each sheet is marked with the date when the last data was secured for the map and sometimes the date of issue.

Arrows showing the direction of magnetic north and also of geographic north appear on each sheet either at the center or on one of the margins.

Battle Maps

Battle maps are large scale maps on which are shown enemy troops and in certain cases defensive and offensive organizations. These are made at army headquarters by the surveyors and published. They have an official character and carry the same message as the staff map, a smaller scale map issued to all officers and non-commissioned officers, and they take precedence, to the exclusion of all other documents, for all the names to be employed in orders, instructions, and reports.

In addition to the battle maps the battery commanders are furnished with three other important sheets of information.

1. **Aerial Photographs** which are now distributed to the artillery in fairly large numbers, especially during a large engagement when there is not sufficient time to issue the information secured by photography in the form of revision of battle maps and it is desired to give this information immediately to the batteries.

2. **Lists of the Points of General Control** called "Control Sheets" which give the exact location of numerous points in the battle area for use in the battery topographical work or in firing. These points are very exactly located by the triangulation detachments and since new reference points are continually necessary they are issued frequently.

3. **Daily Bulletin of Information** containing all accurate information with respect to targets, particularly new ones; issued by the artillery information service.

The two latter sources of information besides aiding the battery in its mission serve also as notes for the revision of the battle map so as to keep it always up to date.

The area of operations on the Western Front, and indeed the whole theater of the war in Europe, is so well mapped that the usual method has come to be that of firing by map. The knowledge of maps has thus taken on a much greater importance for the field

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artilleryman. Maps based on the old systems of projection were not suited to this work, and new maps have been made in which angles and distances are preserved true in as great a measure as possible. These maps are supplied by the topographical sections of the army corps, and are kept up to date by revisions and bulletins from time to time, so that all important changes in the works of the enemy are shown.

The Orienting Line

In accurate map firing the exact location of the guns must be known. To obtain this information certain topographical operations are necessary, part of which are done by the battalion orienting officer and part by the battery officers. The work of the orienting officer can be done before the battery is in position and even before definite positions for the pieces have been selected. He establishes near each battery an orienting line located with reference to certain points which can be clearly indicated both on the ground and on the map. This line, established as nearly parallel as possible to the line of the guns, is indicated by a series of place marks.

The coördinates of this line are given to the battery commanders who plot it on the battery plane table. The guns having been placed in position their exact location on the map is found in the following manner: Orient the plane table at one of the markers on the orienting line. Take a sight toward the panoramic sight of the directing piece and draw a line to it on the plane table. Traverse to the directing piece and set off its distance on the ray drawn on the plane table. To be sure that the piece is accurately located, the traverse should be continued to some other marker on the orienting line. At times it will be necessary to include every piece in this traverse.

When it has been impossible for the battalion orienting officer to complete this preliminary work it must be done by battery officers. As soon as possible this information will be transferred from the plane table, which is a topographical instrument, to the firing board, which is a means of measuring deflection and range.

The Battery in Base Deflection

The battery having been accurately located one of the pieces, usually the right, is chosen as a base piece. The battery commander selects a point, usually in the lines of the enemy and within the sector, which is called the base point. This point may be the registration mark or a target. To establish the battery on the base line the battery commander gives the base piece the deflection necessary to lay it on the base point mentioned above. The line

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from the base piece to the base point is the base line. The battery is said to be on the base line when the base piece is laid on the base point and the other pieces are laid parallel to it. The calculations are made from the map, and later verified by firing on the registration mark.

The base angle is the angle between the base line and the orienting line, and is determined by drawing these two lines on the firing board and measuring the angle between them with a protractor.

In establishing the base piece on the base line, a number of cases arise, and one or two of these will be considered. If a B. C. telescope or aiming circle is used, the instrument may be laid with its zero parallel to the base line, and then by reciprocal laying the base piece is given its deflection and laid on the base line by sighting on the instrument. Just as in reciprocal laying, the laying of the piece should be checked by repeating the process, as the gun has probably shifted the position of the sight in laying. If the work is done with a plane table only, the board should be set up at some point on the orienting line and then oriented. With an alidade sight on the base piece and draw a line the full length of the alidade. With a protractor measure the angle between this line and the base line. Give this angle as a deflection to the gun and have the gunner lay his piece by sighting on a pencil held vertically at any point of the line drawn toward the gun. Repeat the process, just as in reciprocal laying, until the sight no longer moves in laying the piece. The piece should then be referred to some aiming point by the methods outlined in Drill Regulations in measuring the deflection, and this base deflection recorded.

This data is recorded and used: (a) On the firing board; (b) in the data book or target book.

The firing board is simply a sheet of gridded paper (preferably 1 to 10000 grid, if a board big enough to show ranges at this scale can be obtained). The position of each gun is plotted accurately on the board, together with all important targets, and ranges, bearings, etc., which are determined by drawing in the G-T line and measuring with ruler and protractor. The base line and orienting line are also drawn on the firing board. G-T lines should not be drawn all the way to the gun as so many rays coming together would obliterate the plotted position of the guns. **Nothing save these** plottings, and a letter or symbol to identify each target, should appear upon the board.

All data so determined is called **map** data, and must be corrected for atmospheric conditions, weight and kind of projectile, etc., before being given to the guns.

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The target book should show, in addition to all the topographical data relating to the battery position, the following data concerning each target: map location (X, Y, and Z), map range, and map deflection; whatever information is needed in order to determine projectile, fuse, etc., to use, and the adjusted ranges and deflections (reduced to standard conditions) as determined every time the target is taken under fire, together with a statement of the observation used and result achieved, if known.

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CHAPTER X

RECONNAISSANCE

WHILE it is true that the artillery cannot alone bring victory and is dependent upon the other branches of the service for the securing of information and the location of the enemy, still because of the technical and particular information that is required for proper artillery work certain information must be obtained by the artillery itself. The artillery should obtain and use every bit of information available from every source. It should be remembered that the best results cannot be obtained unless the battery is placed in the most favorable position with proper communication and information regarding the enemy. In addition to this the guns should be placed in a well concealed and protected position without the knowledge of the enemy in order that they may surprise him with a sudden and effective fire.

Built upon these strengths and weaknesses of artillery is the technique of using it. In order to use artillery effectively, the artillery officer must know in the first place the plan of the commander of the combined arms. He must know the ground where the action is going to take place. He must form his own plan for assisting the infantry. He must carry it out.

The guns themselves are not close to the head of a column. The action is usually developing before they get into position. But in order to know what is going on the artillery commander is as far front as he is permitted to go. Usually he is with the commander of the troops. He has an eye much farther to the front in the person of his liaison officer. Certain information can be obtained from the cavalry and infantry, but their scouts and patrols are not trained to see what artillerymen must know.

After this information has been obtained it must be sent back to those who can use it. This is accomplished by an elaborate system of agents and assistants. In a single battery, the battery commander's detail are such assistants.

It is a fundamental principle of field artillery that the comman-

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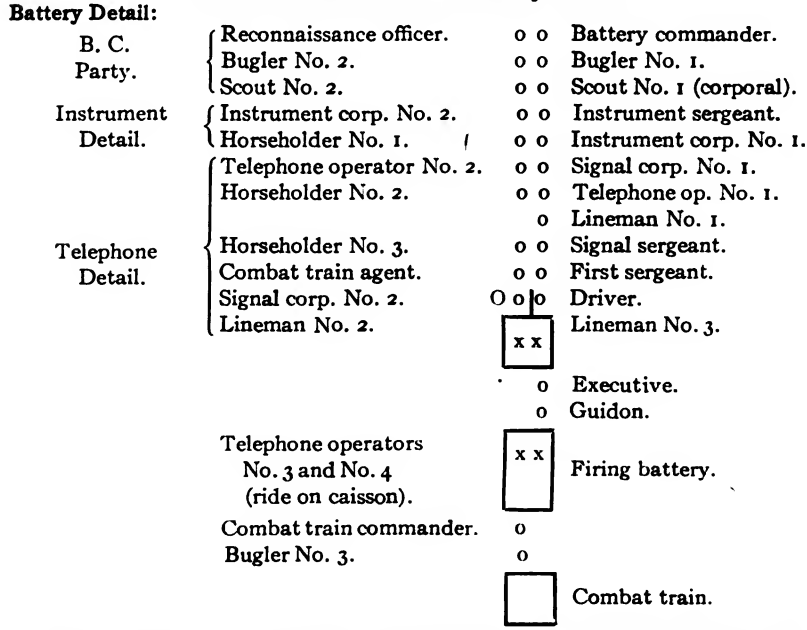
der must get ahead. He must untie himself from his unit and go forward. While he is forward he must make his decisions and certain preparatory arrangements. His reconnaissance must be careful and thorough. Once a battery is in position it is rather difficult to get it out again. It is of the greatest importance to get guns into position before the enemy has put his in position. But it is more important to get them in right than first. For if they are not put in right they will have to be moved and the enemy will be ready before you are.

Reconnaissance is only common sense. Some person or party must precede the battery to select a suitable position. This is the duty of the battery commander and his detail.

To this end battalion and battery details have been formed. These details contain no surplus men. Every one has specific and necessary duties to perform. The composition and arrangement of the detail has developed by experience and actual use of the detail will demonstrate the effectiveness of its organization. The position and duties of every man, both on the march and during an engagement, should be known by every member of the detail in order to facilitate accurate and speedy results with the least possible confusion.

The Formation of the Battery Detail



Total enlisted: 1 first sergeant, 2 sergeants, 6 corporals (includes one as agent to Bn.), 3 buglers, 14 privates.

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General Duties—Battery Detail:

Personnel.	*Duty.*	*Information necessary to perform the duty.*
Bugler No. 1.	1. Orderly to Battery Com.	
	2. In charge of led horses.	2. Position of led horses.
Bugler No. 2.	1. Orderly to reconnaissance officer.	
	2. Horseholder for scouts.	
Scouts.	1. Messengers or runners.	
	2. May temporarily perform the duty of any member of the detail.	
Instrument Sergeant.	1. Commands battery detail.	1. Only when senior to the signal sergeant.
	2. Commands instrument detail.	
	3. Keeps his detail under cover.	3. Location of the enemy.
	4. Supervises the setting up of instruments and plotting board.	4. Location of O. P. What instruments are to be used.
	5. Computes data.	5. Targets, base point, aiming point, location of guns.
	6. Observes.	6. Location of enemy, location of friendly troops, limits of sector.
	7. Records and transmits data.	
Instrument Corporal No. 1.	1. Operator of battery commander's observing instrument.	1. Which instrument is to be used and location of O. P.
	2. Should be able to perform duties of instrument sergeant.	
Instrument Corporal No. 2.	1. Operator of aiming circle.	1. Where instrument will be needed.
	2. Assistant to instrument corporal No. 1, or signal sergeant.	
Signal Corporal No. 1.	1. Switchboard operator.	1. Position for switchboard; number of lines he will have; what the lines connect him with.
	2. Should be able to perform duties of signal sergeant.	
	3. Flagman or projector operator.	3. What station he is to communicate with.

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	4. Send linemen to repair lines that are not working properly.	4. Whether line is out entirely, or working badly.
Telephone Operator No. 1.	1. Operator at guns.	1. Location of telephone station at guns.
	2. Flagman or projector operator.	2. What station he is to communicate with.
	3. Should be able to operate switchboard.	
	4. May be required to act as gun marker.	4. No. of gun he is to mark. Direction of fire. Direction of line of guns. Aiming point.
Telephone Operator No. 2.	1. Operator at O. P.	1. Location of O. P., exact location of telephone.
	2. Flagman or projector operator.	2. What station he is to communicate with.
	3. Send linemen to repair the line when necessary.	3. Whether line is out entirely, or working badly.
	4. Should be able to operate switchboard.	
Telephone Operators No. 3 and No. 4.	1. Reliefs or recorders for other operators.	
Signal Corporal No. 2.	1. In charge of linemen, reel cart, and telephone lines.	
	2. Lays and repairs telephone lines.	2. What lines to lay. What kind of wire to use. Nature of trouble.
	3. Reel cart operator.	
	4. Flagman.	4. What station to communicate with.
Linemen No. 1, No. 2, and No. 3.	1. Assistants to signal corporal No. 2.	
	2. Should be able to perform same duties as signal corporal No. 2.	
Signal Sergeant.	1. In charge of battery detail.	1. If senior to the instrument sergeant.
	2. In charge of telephone detail.	
	3. Establishes communication system.	3. What kind of communication is desired. What method of duplicating the system is most practicable. Location of all communication stations.

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		What equipment is at hand for his purpose. What lines are most important. What lines should be maintained at all costs.
	4. Should be able to perform the duty of any member of the telephone detail.	
	5. Marks the route if the 1st Sergeant is not present.	
Combat Train Agent.	1. Agent between executive and the combat train.	1. Location of combat train and location of guns.
Bugler No. 3.	1. Orderly for combat train commander. May act as C. T. A.	
Guidon.	1. Agent between executive and limbers.	1. Location of guns and limbers.
Horseholders.	1. Horseholders for various details.	1. Position of led horses.
First Sergeant.	1. Agent between the battery commander and the executive.	1. Position of guns and limbers. Gait. Formation for approach. Direction of fire. Line of guns. Aiming point. General location of O. P.
	2. Marks the route.	
Any member of the Detail.	1. Route marker.	1. What direction, or road, the battery is to take. (They should meet the officer or N. C. O. commanding the unit they are to guide twenty-five or fifty meters from the point where the unit will change direction and explain any special directions they themselves have received.)
	2. Should be able to talk over the telephone or to make repairs on telephone lines.	

NOTE: If any member of the detail lacks the necessary information to properly perform his duty he should promptly ask for it.

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How to Use the Details

"How to use the detail" may be described several different ways. The most common one is to tabulate in detail just what each man is required to do; but that method does not explain when the man is to perform each of his many duties. The use of the detail can be—and should be—varied to suit any case. For that reason no hard and fast rules should be laid down when prescribing the duties to be performed by the individual members.

General duties assigned to the different subdivisions:

The B. C. party or reconnaissance party makes the reconnaissance; selects the position for guns and O. P.; issues the necessary instructions for occupation and organization of the position.

The instrument detail organizes the O. P.; observes.

The telephone detail installs and maintains communication no matter what its nature; marks the route.

The radio detail establishes communication with the air service.

The liaison detail establishes communication with the infantry.

The senior officer or non-commissioned officer in each subdivision directs the operations of that subdivision.

The following narrative shows what use may be made of the individual members of the detail. (The assumed tactical situation is typical of those which continually arose in France during offensive movements.)

Advance of a Battery which has been Temporarily held back in Observation

The battery is marching forward from its post of observation. The battery commander receives the following written message from the battalion commander. (The message is delivered by the battery's agent, who returns as soon as the battery commander tells him that the message is understood.)

Gisors,
17 July, 1918.
10 o'clock.

To: C. O. Battery "E," 400th F. A.

1. You know the situation.

2. This battalion's position is on both sides of the GISORS-CHAUMONT road in the vicinity 600 meters west of the western exit of GISORS. "D" and "F" batteries are north of the road.

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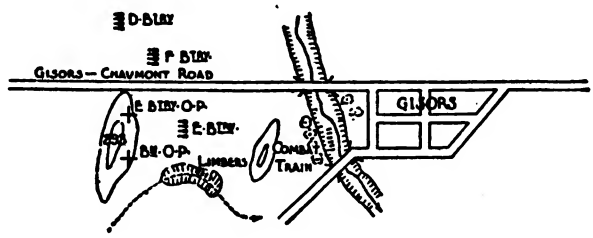
3. Your battery will occupy a position south of the road. Use Hill 293 for your O. P. Minimum range must be 2000 meters or less.

4. I will be at Hill 293 after 10.30 o'clock.

JONES,
Major 400th F. A.

The battery commander directs his R. O. to form the battery for action without halting. He locates Hill 293 on his map and makes a quick study of the map details in that vicinity. He then rides opposite the middle of the detail so that everyone can hear, and says: "We go into position south of the main road leading west from Gisors at a point about 600 meters west of the town. (Point-



ing:) That is Gisors. I will go forward with the entire detail. The battery will follow at a walk. I will mark the route. Posts." He then places himself at the head of the detail, signals "trot," and moves out.

At the eastern entrance to Gisors he turns south on a road which appears to skirt the town. Here the first sergeant posts horseholder No. 3 with instructions to direct the battery along the road taken by the battery commander. When the battery arrives, horseholder No. 3 advances to meet it and explains to the executive that the battery commander took this road (pointing). Horseholder No. 3 then trots on to join the detail. He rides about 300 meters when he meets lineman No. 1, who tells him to take the right fork and continue on. At the southwestern edge of the town he finds the detail. It was at a walk and came to a halt just as he joined it.

The battery commander calls, "Combat train agent." The Combat train agent moves quickly up and answers, "Here." Battery commander says, "The combat train will take post there (pointing) under cover of that high bank. You will join the battery just this side of that hill (pointing to Hill 293). Tell the executive which way I go." The battery commander moves across the field with the detail at a trot. The combat train agent watches them

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until they disappear over a crest and makes a mental note of where he last saw them.

Lineman No. 1 appears and is directed by the C. T. A. to the point where he last saw the detail and at the same time is told that he, the C. T. A., expects to join the battery just this side of that hill (pointing to Hill 293).

Next the battery appears about 100 meters away. The C. T. A. rides toward the executive and directs him the same as he did Lineman No. 1. He also tells the executive that the battery commander ordered the combat train posted there (pointing).

He then rides back along the column and informs the C. T. C. of the battery commander's orders, riding with the C. T. C. to the selected position. After the combat train is posted he informs the C. T. C. how he was instructed to join the battery and rides away.

The battery commander, having arrived with the detail on the eastern slope of Hill 293, halts the detail. He then rides rapidly over, and examines the ground for a suitable position for guns and limbers. He decides on a gun position just south of the Gisors-Chaumont road, distance about 200 meters, from which the guns can easily clear the crest at about 1800 meters. He decides to put the limbers in the bottom of a dry watercourse about 200 meters south of the guns. The switchboard he decides to put under a small tree near the left gun.

He calls, "Scouts, first sergeant, signal sergeant, and instrument sergeant." They all move quickly up and report. The battery commander says (pointing as he gives instructions), "The right gun will be there and the left gun there. Direction of fire, west, parallel to that road. The limbers will be posted in that dry creek bottom 200 meters from here. The switchboard will be under this tree. The led horses will be with the limbers. The O. P. will be on that hill. That looks like the Bn. switchboard across the road. Scout No. 2, go and see. If it is, tell them where our switchboard is. Are there any questions?" Scout No. 1 asks for the aiming point and is told that it will be, "That lone tree you can see about 4000 meters to the left rear." The battery commander then moves up the slope of Hill 293, accompanied by the R. O. and bugler No. 1.

The first sergeant rides back to join the battery. Scout No. 2 rides to the battalion switchboard and points out to the man there the location of the battery switchboard.

Scout No. 1 dismounts, turns his horse over to bugler No. 2, and posts himself at the position of the right gun. Bugler No. 2 goes with the led horse to the position of the limbers. The instrument sergeant conducts the instrument detail up the slope of Hill 293.

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The signal sergeant calls the telephone detail to him and says: "The switchboard will be under this tree. The O. P. will be on that hill where you see the battery commander. The battalion wire will probably come in from across the road. Telephone communication will be duplicated by semaphore. Use light wire. The reel cart will take post just this side of bugler No. 2. The limbers will be at the same place. Linemen No. 2 and No. 3 will watch for the battalion wire-detail and help them get in here."

Scout No. 2 now returns and tells the signal sergeant, in the presence of lineman No. 2 and No. 3, that the battalion wire will be over in about ten minutes. He then turns his horse over to bugler No. 2 and proceeds to the O. P. on foot.

Horseholder No. 2 takes the horses of signal corporal No. 1, operators No. 1 and No. 2 and joins bugler No. 2. Horseholder No. 3 takes the horses of lineman No. 1, signal corporal No. 2, and the signal sergeant, and follows horseholder No. 2. The driver of the reel cart follows horseholder No. 3. Signal corporal No. 2 with lineman No. 1, start running the line toward the battery commander, preceded by operator No. 2. Signal corporal No. 1 sets up the switchboard and his telephone under the tree. He is assisted by linemen No. 2 and No. 3. Operator No. 1 connects his telephone to a piece of wire about sixty meters long, furnished by lineman No. 2; tests his telephone and line and waits to report to the executive. The signal sergeant waits until the battalion wire is in; sees that all lines are tested by signal corporal No. 1; tells the operators to get their flags ready and waits for the arrival of the guns.

The battery commander and R. O. dismount when near the crest of Hill 293, and proceed to the crest on foot. Their horses are taken by bugler No. 1 to the post of the led horses. There he turns the R. O.'s horse over to bugler No. 2 and places himself so that he can see the O. P. The battery commander decides to put the O. P. behind the crest formed by the north slope of the hill. He says to the instrument detail which has dismounted and is waiting a few meters in rear of the crest (the instrument detail horses have been taken by horseholder No. 1 to the post of the led horses): "Set up the B. C. telescope here. I will not need the aiming circle for the present." He and the R. O. then examine the sector to the front for signs of the enemy and suitable registration points. Instrument corporal No. 1, assisted by instrument corporal No. 2, sets up the B. C. instrument. The instrument sergeant at the same time gets out the plotting board and protractors and makes them ready for use near a large bush. The battery commander, having decided to register on a stone wall about 500 meters within the German lines

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(he found this wall plotted on the map), computes the data without reference to the map.

While the battery commander is at the B. C. telescope, telephone operator No. 2 arrives and is told by the R. O. to place his station under that large bush just in rear of the battery commander. Operator No. 2 tests his phone and makes the connections as soon as the wire arrives. Signal corporal No. 2 and lineman No. 1 wait to see that the line is in working order, in the meantime getting out the telephone operator's flags and establishing flag communication with the battery. They can see that lineman No. 3 is the flag operator at the battery. Telephone operator No. 2 reports to the battery commander that communication is established. The battery commander then sends the data for firing on the registration point, the signal sergeant acting temporarily as recorder at the guns.

The battery commander then directs the R. O. to take the plotting board and carefully locate the guns and O. P. The R. O. proceeds on this work, using the aiming circle operator as an assistant. The battery commander continues to compute data for other targets, requiring the B. C. instrument operator to observe the sector with field glasses, and the instrument sergeant to act as recorder.

Scout No. 2 now reports that the switchboard across the road is the Bn. switchboard and that the radio station is also near that point He also asks for further instructions. He is directed to go back to the vicinity of the combat train and look for a suitable watering place for the teams and led horses of the firing battery.

The 1st sergeant met the executive just after the battery passed the C. T. A., and conducted it to the position; advising the executive to approach from the left flank. He also explained that there were a number of scattered bushes large enough to afford considerable concealment if used in conjunction with the camouflage nets. As soon as they came in sight of the position the executive pointed out the route to be followed to the leading chief of section and proceeded at a trot, accompanied by the 1st sergeant. The 1st sergeant pointed to the led horses and said that the limbers were ordered posted there.

Scout No. 1, upon the approach of the executive, faced toward the direction of fire and pointed his flag in that direction, describing with it the arc of a vertical circle; and pointed his left arm toward the position of the left gun. The executive rapidly examined the ground; rode back to the battery; brought the guns up and went into action. The sergeant posted the limbers. The guidon took the executive's horse.

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The guidon later turned his horse and the executive's horse over to the drivers and reported back to the executive on foot.

As soon as the battery arrived at the position, telephone operator No. 3 reported to signal corporal No. 1 as recorder, and telephone operator No. 4 reported to operator No. 1 as recorder and flag operator relieving lineman No. 3 who had been temporarily performing that duty. The executive gives the necessary instructions to the chiefs of sections for concealment. He is asked by telephone operator No. 1 where he desires the telephone station. He directs it to be placed under a large tree just in rear of the third gun. The signal sergeant also hands him the initial data written on a slip of paper.

The signal sergeant now goes to the O. P. and asks for further instructions. The battalion commander now arrives at the O. P. and informs the battery commander that the Bn. O. P. will be located near the top of the hill. He also directs the battery commander to dump about 1200 pounds at the guns and to remove the caissons from the position; that he will in all probability be in the same position for about twenty hours.

The battery commander now turns to the signal sergeant and says: "Establish telephone communication with the combat train. Take the C. T. A. to show you the way. The C. T. A. will remain at the C. T. and act as operator. Show this message to the executive and then take it to the C. T. C." The battery commander writes a message to the C. T. C. ordering up all ammunition to be dumped at the guns and also informing him of the probable stay in the present position. The signal sergeant directs signal corporal No. 2 and lineman No. 1, who have heard the verbal instructions, to get the reel cart and his horse and report to him at the guns. He then goes to the guns and delivers the written message to the executive. He also informs the executive and signal corporal No. 1 that he is going to run a line to the combat train and, that the battery commander has directed the C. T. A. to act as operator at the C. T. He then supervises the laying of the line, using the C. T. A. as a guide. Upon arrival at the C. T. he delivers the written message; explains that a telephone is being installed; waits until it is in working order; returns to the guns. Signal corporal No. 2 conducts the reel cart to the post of the led horses and, with lineman No. 1, reports back to the O. P. Scout No. 2, having reported back, is told to tell the 1st sergeant to water the horses, including the led horses. Scout No. 1 and the aiming-circle operator, together with scout No. 2, are told to assist in watering and feeding the led horses.

That afternoon the battery commander is ordered to reconnoiter, on foot, an advance position. He places the O. P. in charge of the

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R. O. and takes the instrument sergeant, aiming-circle operator, and scout No. 1 with him. He locates the new position on his map, selects an O. P. and registration point, and then computes from the map the Y-azimuth for parallel fire on the registration point, he has stakes driven to mark each gun and the aiming-point stakes. He also examines the landmarks carefully. He does this to prepare for a possible change of position at night. Just as he is about to return he hears heavy machine-gun fire and manages to locate a nest of them. He dopes the coördinates and sends them to the Bn. commander by Scout No. 1.

He returns by way of the infantry Bn. P. C. and informs the infantry commander of his action. He also tells him of the new position.

Toward evening information for the defensive barrage is received. The signal can be seen from the guns so the two instrument corporals and the two scouts are directed to report to the executive as lookouts for the night. The instrument sergeant and operator No. 2 are directed to sleep at the O. P. Signal corporal No. 1 and operators Nos. 1, 3, and 4 form reliefs at the switchboard. The executive's telephone is not manned during the night.

The linemen all sleep near the switchboard where they may be instantly called, signal corporal No. 2 and lineman No. 1 remaining fully dressed during the first half of the night and linemen No. 2 and No. 3 remaining fully dressed during the second half.

At about 2 o'clock the C. T line is reported out of order. The operator tells the linemen as they leave that he heard shells bursting in that direction.

They therefore travel about fifty meters apart. They cannot see, so the line is carried in the hand and permitted to slip through as they walk along.

They find no break, but find the line still out when they reach the C. T. They return along the line about two hundred meters and cut in with a test telephone. They can get C. T. but not the battery. They go about two hundred meters further and cut in again. This time they get the battery but not the C. T. They return toward the C. T. and cut in again, this time they get C. T. but not the battery. They work toward the battery again and finally replace about thirty meters of wire, after which they are able to get both battery and C. T.

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CHAPTER XI

HORSES AND THEIR CARE

A THOROUGH knowledge and understanding of the care and use of the horse is essential to every good field artilleryman. This has never been better illustrated than during the recent war. Because of urgent demand for transportation of troops and because of the shortage of ships, supply of horses to our troops in Europe was limited. The problem was to conserve the horses already in use.

The following extract from a letter from the Chief of Artillery, A. E. F., to the Chief of Field Artillery, U. S. A., on the subject of instruction of officers brings out strongly the necessity of a thorough knowledge of the subject:

"I want to emphasize two things especially: 1st, Get the officers and men as thoroughly disciplined as you possibly can. It is more than knowledge—more than everything else combined, because with it we can soon get the other things: without it we cannot get them at all; 2d, Teach them all you possibly can about the **care** of the horse. We cannot hope in the short time available to make horsemen or good drivers out of them, but if we can teach them how to take care of their animals and how much they can stand, it will help greatly. We are having so much difficulty getting horses over here that we do not get man and horse together until just before the brigades leave the training camps so that there is not time to teach the men anything about the horse. At the front it is well-nigh impossible to teach them these things; so the horses suffer in consequence."

To know how to ride avails nothing without a knowledge of the care of the horse.

Horses in general are classified according to color, height, and weight. To aid in recognition they are described by giving their color, sex, age, height, color of mane, color of tail, points, and by detailing their marked peculiarities. The following are some of the terms used:

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A **snip** is a patch of white (skin and hairs) on the nose.

A **star** is a patch of white hairs in the center of the forehead.

A **blaze** is a streak of white hairs running down the face, starting from the star.

A horse is **bald-faced** when the star and snip are connected by a broad blaze.

When the blaze does not run down the axis of the nose, it is termed a **race.**

White hairs on the legs are almost always limited below by the hoof. They are described by mentioning their upper limits: white heels, white coronets, white pasterns. When the white color extends nearly or quite to the knee or hock, it is termed a **white stocking. A white** foot is, properly, one in which the hoof, as well as the hairs near it, is white.

A horse has **black points** when the mane, tail, and lower legs are black. If the mane, tail, and lower legs are the same color as the rest of the animal, he is **self-colored.**

A mane is **roached** when it is trimmed close on each side, leaving a short, thin line of hair in the center about an inch long, running the length of the crest. It is **hogged** when the mane is closely cut throughout.

A tail is **banged** when it is cut square below the end of the dock. It is **thinned** when it is shortened by pulling and breaking, but not squared off. It is **docked** when the dock and hair both are cut off from eight to eleven inches from the root of the tail.

As to height and weight the horses used in a battery of Artillery are in some organizations considered under two heads, according to their use in the organization, the horses used by the single mounted men and those used in the teams. Chiefs of sections and other single mounted men ride the lighter and more active horses, while the heavier are placed in harness. In other organizations the commanding officer requires the single mounts to be interchangeable with the team horses so that, in case of accident to a team horse, a trained substitute is at hand.

The problems of the field artillery officer with his horses are mainly those of draft and it is with this in mind that the subject of the horse should be considered.

The Artillery Horse

The general conformation of an artillery horse involves a massive form, a compact and blocky body, and a comparative shortness and strength of limb, the whole being in harmonious proportion. Weight

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is a most important consideration, for a true artillery horse must weigh heavy compared with the lighter type. Grouped into classes, the light Artillery horse weighs up to 1300 lbs. and the heavy from 1300 up. In order to pull heavy loads, the artillery horse must possess weight. It becomes very evident that the heavier horse, in harness, brings greater power into the collar than does the lighter horse. The height is not material, provided there is the necessary weight. Artillery horses usually stand from 15 to 17½ hands, though occasional exceptions occur. The light artillery represents the lesser height, and as the weight increases the height may also bear a relationship to it. Quality and substance, as shown in hair, bone, and joints, should be preëminent with this horse. The hair should be fine and silky, even if long, and the bone smooth and attractive, with neatly turned joints. The lower limbs should be generally free from all superfluous flesh. Coarse joints are usually associated with coarse bones and poor feet; often with a coarse and undesirable head.

The action of the artillery horse should be true and bold. Viewed from in front or behind, each leg should move in a line parallel to the median line of the horse.

The feet should be picked up with snap, whether at walk or trot, and carried clear of the ground, showing the sole of the foot clearly in the movement. High knee action is not essential, but a strong, full movement of both knee and hock, without dragging or stiffness, is very important. The artillery horse should have an active gait. A free and easy movement of knee and back is essential to high-class action. In connection with good action the head and neck should be carried high, with style and body action.

Head: The forehead should be broad but not bulging; the eyes full, clear, and prominent; the lids thin and evenly curved. The muzzle should be broad and fine, with large open nostrils. Small nostrils indicate difficulty in breathing and short wind when under strain. The lips should be firm and evenly matched. Loose lips show old age or poor breeding. The ears should be clean cut and proportioned to the size of the head. They should be well set on the head and held erect. The space between the branches of the lower jaw should be ample to give free action to the throat and windpipe. There should be no large glands or loose skin in this region.

Neck: The neck of the artillery horse should be strong and muscular, supporting the head gracefully, and joined smoothly and deeply at the body. Some arch to the neck is desirable. This appears in a very small degree with mares and geldings. A neck with a concave upper border is known as an ewe neck and is unsightly.

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Withers: They should be muscular and smooth. A medium between the high and thin withers and the low broad ones is the most satisfactory.

Shoulders: The shoulders should not be as long and sloping as with a riding horse, but more upright, a happy medium between the straight and sloping shoulder giving the best power and movement for the Artillery horse. Too straight a shoulder promotes excessive concussion and bone trouble of the legs and feet. Smoothness of shoulder is essential, for roughness and prominence will cause soreness and trouble from fit of collar.

Chest: The chest should be full and deep, giving plenty of room for the vital organs. Narrowness behind the shoulders is quite common, and indicates defective constitution. Too much thickness of chest, an unusual occurrence, may cause a swaying movement in action.

Forearm: The forearm should be comparatively long, broadly and strongly muscled in its upper part and gradually tapering to the knee. A powerful forearm on the Artillery horse is highly important and its value is not likely to be overestimated.

Knee: The knee must be broad, as viewed from the front, be well carried back and be amply supported from below. This part should be neat and cleanly jointed. A knee bent backward is called a "calf-knee"; the opposite condition is known as "knee-sprung."

Pastern: The pastern is an important part of the leg. It should be fairly long, be perfectly smooth and free from extra flesh, and stand at an angle of about 45 degrees. At this slope concussion is received in perhaps the least degree, and with least injury to the foot and leg. There is some difference of opinion among horsemen on the length of pastern, some preferring one reasonably long and others one of medium length. The slope is more important than the length, but no doubt better feet prevail where the pastern tends toward length rather than shortness. Sidebones, ringbones, and other foot troubles are most prevalent with short straight-pasterned Artillery horses. As the horse naturally places the foot in action the pressure first comes on the frog and is then distributed over the rest of the foot. If the pastern is straight, the toe and front of the foot strike first and thus the concussion is greatest.

Cannon: The cannon bone is round, but has tendons extending down its back edge, more or less separated from the bone. As viewed from one side, the cannon and its attachment should be deep, amply supporting the knee; and viewed from rear and front, should be quite flat, thus representing the strongest conformation. Often the cannon is tied in beneath the knee, which indicates weakness.

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A long or rounded cannon shows faulty conformation with the best development. A fair girth at the smallest point is 9¾ inches. A large girth, however, does not always indicate proper development as the leg may be coarse and out of proportion.

Fetlock: The fetlock must be smooth and deep with no roughness.

Foot: The foot ought to be large, the hoof dense and preferably dark in color, the sole concave, and the frog large. There is an old saying, "No foot, no horse." Sound feet are absolutely essential to comfort and efficiency of work. The interior of the foot contains very sensitive nerves and membranes. If the foot is too small and contracted, if the frog is too narrow and low, inflammation of the membranes will frequently follow. The ample foot, wide on top and behind, well supported at the heel, and carried true in movement, turning neither in nor out at the toe, is least likely to be troubled with disease.

Body: The body should be short on top, long below, broad along the back, with ribs strongly arched and of great depth. A long back indicates weakness of both constitution and artillery power, while a short deeply muscled back means strength. Ribs well sprung and deep show capacity for the internal organs, indicate a good feeder, and materially add to the weight, which is necessary in the artillery. Usually satisfactory rib development provides a proper body conformation. Often immature horses appear to lack depth of body to some degree, but age and feeding establish the proper proportions. The horse that lacks depth of body will also lack the power of endurance.

Loin: The loin should be broad and thickly muscled. Narrow thin loin indicates weakness of a serious character. Often the loin is depressed directly in front of the space between the hips, a distinctively undesirable conformation. Animals with a sway back as a rule show this weakness of loin.

Croup: The croup should be broad, wide, fairly level, and heavily muscled. A steep croup is very objectionable, and affects both the beauty and power of the horse. A short, steep croup is less strongly muscled than one that is long. The Belgian and French Artillery breeds seem most subject to steepness of rump and low setting of tail.

Thigh: The thigh should be strongly muscled and the quarters should be thick and free. A horse split up high behind, with a thin sharp tapering thigh, lacks good Artillery form at this place. The gaskin, or lower thigh, when properly made, is deep from front to rear and heavily covered with muscle.

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Hock: The hock is a part which requires careful study. As viewed from one side, it should show considerable depth, while from the rear it should possess a certain degree of thinness, though broad in front, the entire joint being free from extra flesh. Thick hocks are very common with Artillery horses, due to various reasons. The joint may be fleshy, puffiness may occur for lack of exercise, or a form of spavin may exist. The hock should be smooth and its various natural curves well defined. As the horse stands in a natural position on his feet, the hocks should be straight and true as viewed from behind, showing no evidence of weakness. Where the hock holds a true position the hind feet also stand true, neither toeing in nor out. When toeing out the points of the hock come too close together, while if toeing in notably the points may be wide apart and the hocks appear springy and weak when in action. The hock should be supported by a wide, thin, clean-boned cannon, which may be about 11 inches in girth at its smallest point. From rear position a line dropped from the point of the buttock or croup viewed from behind, should pass the center of point of hock, cannon, pastern, and foot. From one side it should pass parallel to the entire edge of the cannon and when suspended from the point of the hip should pass the gaskin at the center and drop to the center of the foot. Such a horse is likely to have a good constitution and be able to resist hard work, fatigue, and disease to a maximum degree. On the other hand, a poor constitution is indicated by a shallow, narrow chest, small bones, long loins, coarse neck and head, with thick throat, small, long, and muscular development, short thighs and forearms, small joints, long round cannons, and hoofs of open texture with flat soles.

The temperament is indicated by the manner in which the horse responds to external stimuli. When the horse is spoken to or when he sees or feels anything that stimulates or gives alarm, if he responds actively, quickly, and intelligently, he is said to be of a lively or nervous temperament. On the other hand, if he responds in a slow, sluggish manner, he is said to have a sluggish or lymphatic temperament. The temperament is indicated by the gait, by the expression on the face, and by the carriage of the head and ears. The nature of the temperament should be taken into consideration in an endeavor to ascertain the severity of a given case of illness, because the general expression of an animal in disease as well as in health depends to a large extent on the temperament.

So much for the conformation of the horse. When judging artillery horses, few will be found which fulfill all of the above conditions, but the ones nearest approaching this standard should be

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chosen. Too much attention cannot be given to the legs and feet. A horse having a poor head may give long and satisfactory service but one having a weakness in foot or leg will soon give out when put to the test of a march.

It will be found a good practice after having considered the horse in detail to consider him as a whole. The well bred horse has wonderful symmetry and all parts of his body are well proportioned. The nearer the horse approaches symmetrical conformation the better horse he will prove to be.

Closely following the horse's bodily structure comes the matter of his age. It is logical, when considering two horses of similar conformation, but of different age, to choose the younger because of the longer service he can give, provided, of course, he is not too young. An inspection of the horse's teeth is the most reliable means for estimating his age; although cases have been known in which the age as indicated by the teeth has not been correct.

The horse is provided with two sets of teeth, temporary and permanent. The temporary, or milk, teeth are those of the first growth or dentition. The permanent differs in appearance from the temporary one by being larger, longer, darker, or more yellowish in color, and by having a well marked groove down the anterior or front face of the crown. It does not have the constricted neck which is characteristic of the milk tooth.

The three principal tooth substances are called dentine, enamel, and cement. The dentine composes the main body of the tooth. It is protected by a covering of enamel, which is very white in color and is the hardest of all animal substances. The cement is a yellowish-colored bony material found in the center of the tooth. The grinding surface of tooth is called the table, and there is an unfolding of the enamel on the table of the teeth, which forms in the incisors a cavity, the bottom of which is filled with cement to a depth which varies in different animals. The unfilled portion of this cavity forms what is called the cup. The cups are deeper in the upper incisors than they are in the lower ones. They soon become stained by the food juices so that they appear very black in color. Ordinarily after a lower incisor has been in wear for three years its table surface has been worn down to the cement filling and the blackened cup cavity has disappeared. It is often difficult for the inexperienced observer to determine when the cup has actually disappeared. He expects to see the table surface perfectly level and of uniform color, whereas the enamel, being so much harder than either the dentine or the cement, stands in relief on the table surface, and envelops a very shallow and sometimes slightly stained depression (of cement) for

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several years after the black cup cavity is considered to have disappeared. In the center of the tooth, and extending almost its entire length, is the pulp cavity channel, which in life is filled with a fleshy tissue or pulp through the medium of which the tooth derives its nourishment. As the tooth is worn off with age the outer extremity of the sensitive pulp, which would otherwise become exposed, is changed into a yellowish-colored ivory-like substance that completely fills and closes the cavity. Hence, when the tooth has worn down to the pulp cavity, the latter appears on the table surface (just in front of the remains of the cup) as a yellowish-colored mark called the dental star. This usually makes its appearance when the animal is eight years old, although in very hard teeth it is often not apparent until about eleven years. Depending upon the hardness of the dentine and the character of the food, the teeth wear away at the rate of about one twelfth of an inch per year. As an incisor is not of uniform shape or size from its crown to its roots, it is at once apparent that wear will continually change the form of its table surface.

Dentition of the Horse

Kind	Number	When Appear	When Replaced
Incisors	Center	birth	2½ years
	Middle	4 to 6 weeks	3½ years
	Corner	6 to 9 months	4½ years
Canines		4 to 5 years	
Molars	First	Birth	2½ years
	Second	Birth	2½ years
	Third	Birth	3½ years
	Fourth	10 to 12 months	
	Fifth	2 years	
	Sixth	4 to 5 years	

By their growth, changes of form, and wearing, the teeth of the horse furnish a very reliable guide to determine the animal's age. In the adult animal they number from thirty-six in the female to forty in the male, and are classed according to their location, form, and functions, as incisors, canines, and molars. The incisors, or cutters, occupy the front part of the mouth. They are twelve in number, 6 in the lower, and 6 in the upper jaw. In each jaw there are two central, two lateral, and two corner incisors. The canines, or tushes, occupy the front part of the interdental space. The tushes are usually absent in the mare, or if present, are very small. They are four in number, two in each jaw. The molars, or grinders,

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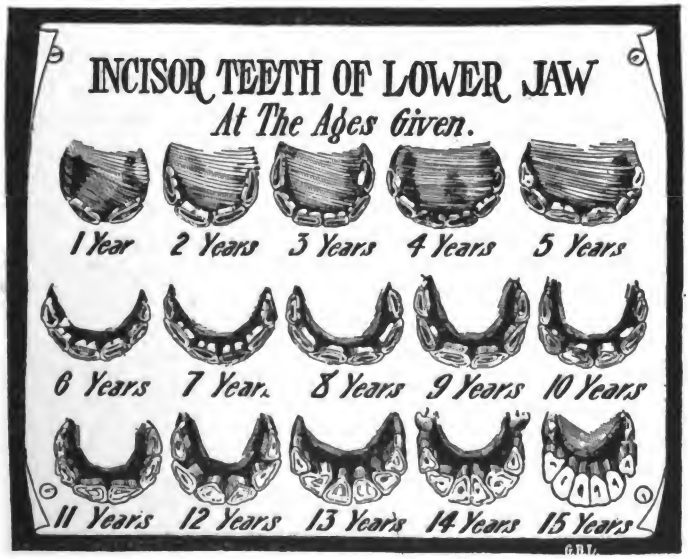
occupy the back part of the mouth. They are twenty-four in number, six in each side of each jaw. Naming from front to rear, they are designated first, second, third, etc. Quite frequently supplementary molars, called "wolf teeth," are present. If so, they appear directly in front of the first molar, in the upper jaw. To obtain the best view of the mouth, grasp the upper lip firmly with the right hand, and place the left in the interdental space from the right side, using the thumb to depress the lower lip, and the back of the hand to press the tongue upward and backward. In this way the right hand serves as a twitch to hold the horse, while the left one uncovers the lower incisors.

The age of horses by the teeth is determined by shedding and appearance of the teeth up to four years, according to table. Cups wear out of center pair of incisors of lower jaw at about six years; middle pair of incisors at about seven years; and corner incisors at about eight years; cups wear out of center incisors of upper jaw at nine years, middle pair at eleven years, and corner incisors at about twelve years. Quality of the teeth, kind of food, and the way the teeth fit together to be considered.



Another indication of the age is the angle made by the front surfaces of the upper and lower teeth. While the horse is young this angle is nearly 180 degrees. As the horse grows older the angle becomes more acute.

After looking the horse over for conformation, and finding that

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he fulfills the requirements, the next important step is to examine him for soundness.

To be theoretically sound a horse must have no disease or other condition that interferes or is likely to interfere with his usefulness. A horse may have a disease from which he will recover. At the time of the examination he will be technically unsound.

A blemish, such as Roman nose, wire cut, and scars, does not interfere with his usefulness, but is unsightly.

An examination for soundness should be systematic and thorough, although it may be rapidly done. Examination should be made with the horse in the stall: as he backs out, stands at rest, and in motion. In the stall, examine to see whether the horse cribs or weaves, or has any other stable habit which is objectionable. As the horse backs out of the stall, he may show peculiar use of the hind legs or imperfect control, due to serious disorders of the nervous system. Very frequently the first intimation of spavin may be had as the horse is made to step from side to side, particularly as he steps toward the spavined leg.

At Rest: With the horse at rest the observer should begin in front and examine the ears for hearing, for tumors that may develop around the base, for split ears, etc.

The eyes should be examined to test the sight, bearing in mind that moon blindness, which recurs at intervals and leaves the eye more or less normal between times, still shows a weakened or squinting appearance that is suggestive.

The nasal chambers should be examined for ulcers, scars, or discharges which would suggest possible glanders.

The teeth should be examined for evidence of cribbing, for age, and for a condition commonly known as parrot mouth, which interferes with a horse's feeding, *i. e.* overhanging upper jaw teeth.

The lips should be examined for evidence of paralysis. The glands between the portions of the lower jaw should be examined particularly with reference to glanders.

The poll should be examined for scars or other evidences of present or previous poll-evil.

The withers should be examined for scars, for discharging sores, and other evidences of fistulous withers.

The shoulders should be examined for sore neck and particularly so-called collar boils. The latter are either flat and broad or more prominent tumors, which will usually subject a horse to sore shoulders whenever he is put to work.

While passing along the side and flank the breathing should be observed, as to whether it is even and regular, or jerky, suggesting

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heaves. The flank and lower part of the abdomen must be examined for possible ruptures.

Stepping behind the horse, the two hips are compared for evidence of fractures, or what is commonly known as hipped or hip shot. This disorder does not interfere seriously with the horse's working ability, but gives the horse a very awkward appearance.

An examination should be made for the following unsoundnesses in the leg:

Splints: Are found on the inside of the leg, from the knee, near which they are frequently found, downward to about the lower third of the principal cannon bone. They are of various dimensions, and are readily perceptible both to the eye and to the touch. They vary considerably in size, ranging from that of a large nut downward to very small proportions. In searching for them they may be readily detected by the hand if they have attained sufficient development in their usual situation, but must be distinguished from a small, bony enlargement that may be felt at the lower third of the cannon bone, which is neither a splint nor a pathological formation of any kind, but merely the button-like enlargement at the lower extremity of the small metacarpal or splint bone.

Ringbone: Extends around the coronary band when on the front of the foot, and even when not very largely developed, assumes the form of a diffused convex swelling. If situated on the lower part, it will form a thick ring, encircling that portion of the foot immediately above the hoof; when found on the posterior part, a small sharp bony growth, somewhat projecting, either on the inside or outside and sometimes comprising the entire coronet.

As with splints, ringbones may result from severe labor in early life, before the process of ossification has been fully perfected; or they may be due to bruises, blows, sprains, or other violence; injuries of tendons, ligaments, also may be among the accountable causes.

Spavin: Bone spavin is an exostosis of the hock joint. The general impression is that in a spavined hock the bony growth should be seated on the anterior and internal part of the joint, and this is partially correct, as such a growth will constitute a spavin in the most nearly correct sense of the term. But an enlargement may appear on the upper part of the hock also, or possibly a little below the inside of the lower extremity of the shank bone, forming what is known as a high spavin; or, again, the growth may form just on the outside of the hock and become an outside, or external, spavin. Serious in its beginning, serious in its progress, it is an ailment which, when once established, becomes a fixed condition which there is no known means of dislodging.

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Blood Spavin: Is situated in front and to the inside of the hock and is merely a varicose or dilated condition of the vein. It occurs directly over the point where the bog spavin is found, and has thus been frequently confused with the latter.

Bog Spavin: Is a round, smooth, well-defined, fluctuating tumor situated in front and a little inward of the hock. On pressure it disappears at this point to reappear on the outside just behind the hock. If pressed to the front from the outside it will then appear on the inside of the hock. On its outer surface it presents a vein which is quite prominent, running from below upward, and it is to the unnatural dilation of this blood vessel that the term blood spavin is applied.

Thoroughpin: Is found at the back and on the top of the hock in that part known as the "hollows," immediately behind the shank bone. It is round and smooth, but not so regularly formed as the bog spavin, and is most apparent when viewed from behind. The swelling is usually on both sides and a little in front of the so-called hamstring, but may be more noticeable on the inside or on the outside.

Sprains: Express a more or less complete laceration or yielding of the fibers of the muscles, tendons, or the sheaths surrounding and supporting them. The usual cause of a sprain is external violence, such as a fall or a powerful exertion of strength with following symptoms of soreness, heat, swelling, and a suspension of function.

Curb: Is the bulging backward of the posterior part of the hock, where in the normal state there should be a straight line, extending from the upper end of the point of the hock down to the fetlock. The cause may be a sprain of the tendon which passes on the posterior part of the hock, or of one of its sheaths.

Capped Elbow: Or "shoe boil," is a term applied to an enlargement often found at the point of the elbow. This lesion is due to injury or pressure of the part while it is resting on the ground. If the leg is flexed under the body so that the hoof or shoe is directly in contact with the elbow, which may occur in horses having an extremely long cannon bone or excessive length in the shoes, the greater part of the weight of the chest is concentrated at this point and the pressure may cause a bruise or an inflammation.

Capped Hock: Is a bad habit of rubbing or striking the partitions of their stalls with their hocks which prevails among some horses, with the result of an injury which shows itself on the upper points of those bones. From its analogy to the condition of capped elbow the designation of capped hock has been applied to this condition.

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Stringhalt: Is an involuntary movement of one or both hind legs, in which the foot is suddenly and spasmodically lifted from the ground much higher than it is normally carried, with excessive flexion of one bone upon the other. This peculiarity is usually prominent, although it may disappear with work, only to reappear after a short rest. Veterinarians and pathologists are yet in doubt in respect to the cause of this affection, as well as to its essential nature.

Flatfoot: Is that condition in which the sole has little or no convexity. It is confined to the fore feet, which are generally broad and low-heeled.

In flatfoot there can be little or no elasticity in the sole, for the reason that it has no arch, and the weight of the animal is received on the entire plantar surface, as it rests upon the ground instead of on the wall. For these reasons such feet are particularly liable to bruises of the sole and corns. Horses with flatfoot should be shod with a shoe having a wide web, pressing on the wall only, while the heels and frog are never to be pared. Flatfoot generally means weak walls, and as a consequence the nails of the shoe are readily loosened and the shoe cast.

Clubfoot: Is a term applied to such feet as have the walls set nearly perpendicular. When this condition is present the heels are high, the fetlock joint is thrown forward or knuckles, and the weight of the animal is received on the toes. The toe should not be pared, but the heels are to be lowered as much as possible and a shoe put on with a long, projecting toe piece, slightly turned up, while the heels of the shoe are to be made thin.

Crooked-foot: Is that condition in which one side of the wall is higher than the other. If the inside wall is the higher, the ankle is thrown outward, so that the fetlock joints are abnormally wide apart and the toes close together. Animals with this deformity are "pigeon-toed," and are prone to interfere, the inside toe striking the opposite fetlock. If but one foot is affected, the liability to interfere is still greater, for the reason that the fetlock of the perfect leg is nearer the center plane.

When the outside heel is the higher, the ankle is thrown in and the toe turns out. Horses with such feet interfere with the heel. If but one foot is so affected, the liability to interfere is less than when both feet are affected, for the reason that the ankle of the perfect leg is not so near to the center plane. Such animals are especially liable to stumbling and to lameness from injury to the ligaments of the fetlock joints. This deformity is to be overcome by such shoeing as will equalize the disparity in length of walls and by proper boots to protect the fetlock from interfering.

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Interfering: An animal is said to interfere when one foot strikes the opposite leg, as it passes by, during locomotion. The inner surface of the fetlock joint is the part most subject to this injury, although, under certain conditions, it may happen to any part of the ankle. It is seen more often in the hind than in the forelegs. It may cause lameness, dangerous tripping, and thickening of the injured parts. Faulty conformation is the most prolific cause of interfering.

Knuckling: Is a partial dislocation of the fetlock joint, in which the relative position of the pastern bone to the cannon and coronet bones is changed, the pastern becoming more nearly perpendicular, with the lower end of the cannon bone resting behind the center line of the large pastern, while the lower end of this bone rests behind the center line of the coronet. While knuckling is not always an unsoundness, it nevertheless predisposes to stumbling and to fracture of the pastern.

Windgall: Joints and tendons are furnished with sacs containing a lubricating fluid called synovia. When these sacs are overdistended by reason of an excessive secretion of synovia, they are called windgalls. They form a soft, puffy tumor about the size of a hickory nut, and are most often found in the foreleg, at the upper part of the fetlock joint, between the tendon and the bone. When they develop in the hind leg it is not unusual to see them reach the size of a walnut. Occasionally they appear in front of the fetlock on the border of the tendon. The majority of horses are not subject to them after colthood has passed. The tumor is more or less firm and tense when the foot is on the ground, but is soft and compressible when the foot is off the ground. In old horses, windgalls generally develop slowly and cause no inconvenience. If they are caused by excessive tension of the joint, the tumor develops rapidly, is tense, hot and painful, and the animal is exceedingly lame.

Overreach: When the shoe of the hind foot strikes and injures the heel or quarter of the fore foot the horse is said to overreach. It rarely happens except when the animal is going fast; hence, is most apt to appear in running and trotting horses. In trotters the accident generally happens when the animal breaks from a trot to a run. The outside heels and quarters are most liable to the injury.

Frostbites: Excepting the ears, the feet and legs are about the only parts of the horse liable to become frostbitten. In mountainous districts, where the snowfall is heavy and the cold often intense, frostbites are not uncommon, even among animals running at large.

Quittor: Is generally seen in but one foot at a time, and more often in the fore than in the hind feet. It nearly always attacks the

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inside quarters but may affect the outside, the band in front, or the heel, where it is of but little consequence. It consists in the inflammation of a small part of the coronary band and adjacent skin, followed by sloughing and suppuration, which in most cases extends to the neighboring sensitive laminæ. Injuries to the coronet, such as bruises, overreaching, and calk wounds, are considered as the common causes of the disease. Still, cases occur in which there appears to be no existing cause, just as in other forms of quittor, and it seems fair to conclude that subhorny quittor may also be produced by internal causes.

Canker: Of the foot is due to the rapid reproduction of a vegetable parasite. It not only destroys the sole and frog, by setting up a chronic inflammation in the deeper tissues, but prevents the growth of a healthy horn by which the injury may be repaired. The essential element in the production of canker is the parasite; consequently, the disease may be called contagious. As in all other diseases due to specific causes, however, the seeds of the disorder must find a suitable soil in which to grow before they are reproduced. It may be said, then, that the conditions which favor the preparation of the tissues for a reception of the seeds of this disease are simply predisposing causes. The condition most favorable to the development of canker is dampness—in fact, dampness seems indispensable to the existence and growth of the parasite; the disease is rarely, if ever, seen in high, dry districts, and is much more common in rainy weather than in dry seasons. Filthy stables and muddy roads have been classed among the causes of canker, but it is very doubtful whether these conditions can do more than favor a preparation of the foot for the reception of the disease germ.

Corns: A corn is an injury to the living horn or the foot, involving the soft tissues beneath, whereby the capillary blood vessels are ruptured and a small quantity of blood escapes which, by permeating the horn in the immediate neighborhood, stains it a dark color. If the injury is continuously repeated, the horn becomes altered in character and the soft tissues may suppurate or a horny tumor develop. Corns always appear in the sole in the angle between the bar and the outside wall of the hoof. In many cases the laminæ of the bar, of the wall, or of both, are involved at the same time. The fore feet are almost exclusively the subjects of the disease for two reasons: First, because they support the greater part of the body: secondly, because the heel of the fore foot during progression is the first place upon the ground whereby it receives much more concussion than the heel of the hind foot, in which the toe first strikes the ground. It may be said that all feet are exposed to corns, and

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that even the best feet may suffer from them when conditions necessary to the peculiar injury are present. Among the causes and conditions which predispose to corns may be named high heels, which change the relative natural position of the bones of the foot and thereby increase the concussion to which these parts are subject; contracted heels, which in part destroy the elasticity of the foot, increase the pressure upon the soft tissues of the heel, and render lacerations more easy; long feet, which by removing the frog and heels too far from the ground deprive them of necessary moisture; this, in turn, reduces the elastic properties of the horn and diminishes the transverse diameter of the heels; weak feet, or those in which the horn of the wall is too thin to resist the tendency to spread, whereby the soft tissues are easily lacerated. Wide feet with low heels are always accompanied with a flat sole whose posterior wings either rest upon the ground or the shoe and as a consequence are easily bruised; at the same time the arch of the sole is so broad and flat that it cannot support the weight of the body, and in the displacement which happens when the foot is rested upon the ground the soft tissues are liable to become bruised or torn.

It is universally conceded that shoeing, either as a direct or predisposing cause, is most prolific in producing corns. A shoe so set as to press upon the sole, or one that has been on so long that the hoof has overgrown it until the heels rest upon the sole and bars, becomes a direct cause of corns. Indirectly the shoe becomes the cause of corns when small stones, hard, dry earth, or other objects collect between the sole and shoe. Lastly, a rapid gait and excessive knee action, especially on hard roads, predispose to this disease of the feet.

Bruise of the Frog: Generally caused by stepping on a rough stone or other hard object. It is more liable to take place when trotting, running, or jumping than when at a slower pace. A stone wedged in the shoe and pressing on the frog or between the sides of the frog and the shoe, if it remains for a time produces the same results. A cut through the horny frog with some sharp instrument or a punctured wound by a blunt-pointed instrument may also cause suppuration and gangrene of the plantar cushion. Broad, flat feet with low heels and a fleshy frog are most liable to these injuries.

Contracted Heels, or Hoofbound: Is a common disease among horses kept on hard floor in dry stables, and in such as are subject to much saddle work. It consists in an atrophy, or shrinking, of the tissues of the foot, whereby the lateral diameter of the heels is diminished. It affects the fore feet principally, but is seen occasion-

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ally in the hind feet, where it is of less importance, for the reason that the hind foot first strikes the ground with the toe, and consequently less expansion of the heels is necessary than in the fore feet, where the weight is first received on the heels. Any interference with the expansibility of this part of the foot interferes with locomotion and ultimately gives rise to lameness. Usually but one foot is affected at a time, but when both are diseased the change is greater in one than in the other. Occasionally but one heel, and that the inner one, is concentrated; in these cases there is less likely to be lameness and permanent impairment of the animal's usefulness.

Sand Cracks: May occur in any part of the wall, but ordinarily are only seen directly in front, when they are called toe cracks; or on the lateral parts of the walls when they are known as quarter cracks.

Toe Cracks: Are most common in the hind feet, while quarter cracks nearly always affect the fore feet. The inside quarter is more liable to the injury than the outside, for the reason that this quarter is not only the thinner, but during locomotion receives a greater part of the weight of the body. A sand crack may be superficial, involving only the outer parts of the wall, or it may be deep, involving the whole thickness of the wall and the soft tissues beneath.

The toe crack is most likely to be complete—that is, extending from the coronary band to the sole—while the quarter crack is nearly always incomplete, at least when of comparatively recent origin. Sand cracks are most serious when they involve the coronary band in the injury. They may be complicated at any time by hemorrhage, inflammation of the laminæ, suppuration, gangrene of the lateral cartilage and of the extensor tendon. Relative dryness of the horn is the principal predisposing cause of sand cracks. Heavy shoes, large nails, and nails set too far back toward the heels, together with such diseases as canker, quittor, grease, and suppurative corns, must be included as occasional causes of sand cracks.

Sidebones: A sidebone consists in a transformation of the lateral cartilages found on the wings of the coffin bone into bony matter by the deposition of lime salts. The disease is a common one, especially in heavy horses used for draft, in cavalry horses, cow ponies, and other saddle horses and in runners and trotters.

Sidebones are peculiar to the fore feet, yet they occasionally develop in the hind feet, where they are of little importance since they cause no lameness. In many instances sidebones are of slow growth and, being unaccompanied with acute inflammation, they cause no lameness until such time as, by reason of their size, they interfere with the action of the joint. Sidebones often grow in heavy horses without any apparent injury and their development has been

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attributed to the over-expansion of the cartilages caused by the great weight of the animal. Blows and other injuries of the cartilages may set up an inflammatory process which ends in the formation of these bony growths. High-heeled shoes, high calks, and long feet are always classed among the conditions which may excite the growth of sidebones. They are often seen in connection with contracted heels, ringbones, navicular disease, punctured wounds of the foot, quarter cracks, and occasionally as a sequel to founder.

Ringbones: Is the growth of a bony tumor on the ankle. This tumor is, in fact, not the disease, but simply the result of an inflammatory action set up in the bone tissue proper of the pastern bone.

Injuries, such as blows, sprains, overwork in young, undeveloped animals, fast work on hard roads, jumping, etc., are among the principal exciting causes of ringbone. Horses most disposed to this disease are those with short, upright pasterns, for the reason that the shock of locomotion is but imperfectly dissipated in the forelegs of these animals. Improper shoeing, such as the use of high calks, too great a shortening of the toe and correspondingly high heels, predispose to this disease by increasing the concussion of the feet.

In Motion: The horse should be examined while walking and trotting. The movement of the neck and head are studied as he comes toward the observer; then, as he passes by, the movements of the limbs are noted as to the height to which they are raised; the bend of the joints whether easy and natural or otherwise. The way in which the foot lands upon the ground, whether flat, on the toe, one side, or on the heel, is to be noted and considered. As the horse passes from the observer, the movements of the hips and hind legs are noted with a view to detecting lameness in those parts. Examination in motion on a hard road or pavement should be made, especially to bring out diseases of the feet. Then motion in deep mud or in snow should be studied. If these are not available, the horse should be made to step over a rail or plank held up about a foot from the ground in order to detect or make more prominent possible soreness or lameness in the shoulder or hip.

The Lungs: Finally, the horse should be given vigorous exercise on a full stomach. For instance, a run to a heavy wagon, or a short run uphill to determine whether the lungs are normal, or, in other words, for the purpose of testing his wind. It is possible to partially disguise abnormal breathing while the horse is at rest, but it is practically impossible to do so if the horse is given violent exercise, and the latter should preferably be done after feeding and watering. The pulse and temperature are also taken at this time.

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Care of the Horse

Grooming: To keep the sound horse in good health, he must have thorough and regular grooming. He must be carefully fed and his stable must be kept in a sanitary condition. To understand better the relation between grooming and the health of the horse, a study of the skin is necessary. The skin consists primarily of two parts:

1. The superficial layer containing no blood vessels and known as the epidermis. This layer consists of cells placed side by side, and more or less modified in shape by their mutual compression and by surface evaporation and drying. As these cells dry, they form scales which fall off continually and form dandruff.

2. The second or deeper layer contains a large number of blood vessels and is called the dermis or true skin. This layer is formed of somewhat rounded cells that have the selective power to determine what they shall take up for their own nourishment and what they shall admit into the circulation from without. Thus, certain agents, like iodine and belladonna, are readily admitted, whereas others, like arsenic, are excluded. This layer contains fibrous bundles, cells, blood vessels, nerves, glands, gland ducts, and hairs.

Hairs grow from follicles, sacs hollowed out in the skin and extending to its deepest layers. The hair itself is formed of the same kind of cells, firmly adherent to one another by a tough intercellular substance and overlapping each other, like slates on a roof, in a direction toward the free end. There are glands ending in the above sacs which secrete an oily substance which gives glow to the hair and prevents its becoming dry and brittle, and keeps the skin soft and pliable.

The fibrous bundles of the true skin contain plain muscular fibers, which are not controlled by the will, but contract under the influence of cold and under certain nervous influences, as in some skin diseases and in chill or fever, and lead to contraction, tightening, or corrugation of the skin, contributing to produce what is commonly called "hidebound." Besides these, the horse's skin is furnished with an expansion of red, voluntary muscle, firmly attached to the fibrous bundles, and by which the animal cannot only dislodge insects and other irritants, but even shake off the harness. The fleshy envelope covers the sides of the trunk and the lower portions of the neck and head, the parts unprotected by the mane and tail, and serves to throw the skin of these parts into puckers, or ridges, in certain irritating skin diseases.

There are numerous, isolated glands, opening directly on the

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surface of the skin, producing a somewhat thicker and more odorous secretion. They are found in large numbers in the folds of the skin, where chafing would be liable if the surface were dry, as on the sheath, scrotum, and inner side of the thigh, around the anus, in the hollow of the heel, beneath the finehorn of the frog, on the inner side of the elbow, on the lips, nostrils, and eyelids. When closed by dried secretion, these glands may become distended so as to form various-sized swellings on the skin, and when inflamed they may throw out offensive, liquid discharges, as in "grease," or produce red, tender, fungous growths, commonly called "grapes."

The cutaneous covering presents such an extensive surface for the secretion of dermis scales, hairs, horn, sweat, and other excretory matters that any extensive disorder in its functions may lead to serious internal disease and death. Again, the intimate nervous sympathy of different points of the skin with particular internal organs renders certain skin disorders causative of internal disease and certain internal diseases causative of affections of the skin. The mere painting of the skin with an impermeable coating of glue is speedily fatal; a cold draft striking on the chest causes inflammation of the lungs or pleura; a skin eruption speedily follows certain disorders of the stomach, the liver, the kidneys, or even the lungs; simple burns of the skin cause inflammations of internal organs, and inflammation of such organs cause in their turn eruptions of the skin. The relations—nervous, secretory, and absorptive—between the skin and internal organs are most extensive and varied, and therefore a visible disorder in the skin may point at once and specifically to a particular fault in diet, to an injudicious use of cold water when the system is heated, to indigestion and **improper grooming.**

The sweat glands of the horse, like those of man, are composed of simple tubes which extend down through the cuticle and dermis in a spiral manner, and are coiled into balls in the deeper layer of the true skin. In addition to their importance in throwing offensive waste products out of the system, these glands tend to cool the skin and the entire anatomy of the animal through the evaporation of their watery secretion. Their activity is therefore a matter of no small moment, as, besides regulating the animal heat and excreting impurities, they influence largely the internal organs through the intimate sympathy maintained between them and the skin.

Chafing is a common cause of diseases of the skin and is especially liable to affect the fat horse between the thighs, by the side of the sheath or scrotum, on the inner side of the elbow, or where the harness chafes on the poll, shoulder, back, breastbone, and under the tail. The accumulation of sweat and dust between the folds of the skin

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and on the surface of the harness, and the specially acrid character of the sweat, in certain horses contributes to chafing. The heels often become congested owing to the irritation caused by the short bristly hairs in clipped heels. Again congestion may occur from friction by halter, harness, or other foreign body under the pastern, or inside the thigh or arm, or by reason of blows from another foot (cutting, interfering, overreaching), finally erythema is especially liable to occur in spring, when the coat is being shed, and the hair follicles and general surface are exposed and irritable in connection with the dropping of the hairs.

"The value of grooming is dependent upon the force with which the brush is used and the thoroughness of the other work. As is seen above, grooming is essential to the general health and condition of the domesticated horse. Horses improperly groomed, with ragged manes, unkept pasterns, feet improperly looked after, form an indication of an inefficient organization. Clean horses, properly harnessed and smartly turned out, add to the esprit of an organization and give a fair indication of the discipline and efficiency."

"**To Judge the Cleanliness of a Horse:** The hand may be passed the reverse way of the hair to get a view of the skin. When the points of the fingers are run firmly against the set of the coat, lines of gray are left on the coat of a dirty skin and the points of the fingers are covered with scurf. Between the branches of the under jaw, under the crown piece of the halter, at the bends of the knees and hocks, under the belly, and between the forelegs and thighs are the places usually neglected when the work is not thorough and which should be looked at when the horse is being inspected."

Besides cleaning the coat, grooming stimulates the circulation and acts as a tonic to the horse. It rests a tired animal, and relieves congestion following a hearty meal by diverting part of the excessive blood supply from the digestive region. Twenty minutes' brisk grooming in the morning and twenty-five in the evening is the right amount to keep the animal's coat clean and skin healthy. More time than that will be appreciated in the satiny coat of the horse. A horse can hardly be groomed too much. The average horse likes to be fussed with and handled. He enjoys having his legs rubbed and his coat brushed. The currycomb is not so much enjoyed. It should be used merely to loosen caked mud or manure on the knees or hocks. Use only the fingers on the mane and tail.

In grooming with the horse-brush, the groom should stand well away from the horse, legs well apart, and, with the brush in the hand next the horse's head and the currycomb in the other, brush the coat with the lay of the hairs, throwing as much of the weight of the

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body into the brush as possible. After three or four strokes with the brush, clean it on the comb. Clean the comb every few minutes by tapping it on the ground in rear of the horse.

The sheath should be frequently washed with Castile soap and water, and never oiled. Oil simply collects and holds dust and makes washing more often necessary. The glands of the skin secrete all the oil needed to keep it in condition.

Keep the long hairs of the muzzle cut short. They have no useful function in the domestic horse and are unsightly.

Keep the fetlock short the year around. In winter it should be an inch and a half long and neatly trimmed. In summer it should be clipped.

Feeds and Feeding

Hand in hand with grooming, goes the feeding of the horse. Constant attention must be paid to regulating the amount and time of feeding according to the condition of the horse and the work he is doing in order to keep him in perfect health and to get the best results.

Forage is any food suitable for horses and can be divided into two general classes: hay and grain. The ration must be sufficiently bulky to keep the stomach and intestines partially filled at all times, as the process of digestion is best carried out in this state. Without sufficient bulk, conditions cannot be maintained, no matter how nourishing the food.

The length of time occupied by stomach digestion in the horse varies with the different feeds. Oats should be given after hay, for if reversed, the hay would cause the oats to be sent onward into the intestines before being fully acted upon by the stomach, and as a result produces indigestion. Experience confirms this. There is another good reason why hay should be given first, particularly if the horse is very hungry, or if exhausted from overwork, namely, it requires more time in mastication (insuring proper mixture of saliva) and cannot be bolted, as are the grains. In either instance, water must not be given soon after feeding, as it washes the feed from the stomach before it is fitted for intestinal digestion.

The stomach begins to empty itself very soon after the commencement of feeding, and continues rapidly while eating. Afterward the passage is slower, and several hours are required before the stomach is entirely empty. The nature of the work required of the horse must guide us in the selection of his feed. Rapid or severe labor cannot be performed on a full stomach. For such labor, feed must be given in small quantity and about two hours before going to

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work. Even horses intended for slow work must never be engorged with bulky, innutritious feed immediately before going to labor. The small stomach of the horse would seem to lead us to the conclusion that he should be fed in small quantities and often, which in reality should be done. The disproportion between the size of the stomach and the quantity of the water drunk tells us plainly that the horse should always be watered before feeding. One of the common errors of feeding, and the one that produces more digestive disorders than any other, is to feed too soon after a hard day's work. This must never be done. A small quantity of hay may then be given but his grain should be withheld for one or two hours. These same remarks will apply with equal force to the horse that for any reason has been fasting for a long time. After a fast, feed less than the horse will eat, for if allowed too much, the stomach becomes engorged, its walls paralyzed, and "colic" is almost sure to follow. The horse should be fed three or four times a day. It will not do to feed him entirely upon concentrated feed. Bulky feed must be given to detain the grains in their passage through the intestinal tract; bulk also favors distention and thus mechanically aids absorption.

Food may be a factor in animal disease when excessive in amount, insufficient, too concentrated, too coarse, bulky, and innutritious for the animal that receives it; poor in quality; when given in a poorly balanced ration or at irregular or improper intervals; when given a very tired or hot animal; when carrying vegetable or animal parasites; or when suddenly changed; and when poisonous.

Excessive Amount: Common tendency to overfeed results in azoturia, heaves, colic, etc., and favors the development of all febrile diseases. Only a certain amount can be absorbed or used; the remainder causes trouble.

Deficiency predisposes to all diseases that are favored by a lessened vitality. Glanders and similar diseases are especially apt to occur or to increase in severity among horses that are poorly fed Deficiency in food mineral matters predisposes toward certain diseases of bone. Deficiency of albumin results in loss of energy and strength, and the animals so fed are apt to be languid and weak.

Sudden Changes of Diet are always dangerous. When desirous of changing, do so very gradually. If a horse is accustomed to oats a sudden change to a full meal of corn will generally sicken him. If we merely intend to increase the quantity of the usual feed, this also must be done gradually. The quantity of feed given must always be in proportion to the amount of labor to be performed. If a horse is to do a small amount of work, or rest entirely from

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work for a few days, he should receive a proportionate quantity of feed and of a laxative nature. If this should be observed even on Saturday night and Sunday, there would be fewer cases of "Monday morning sickness," such as colics and lymphangitis.

Coarse, Bulky, and Innutritious Food may cause colic, indigestion, heaves, and impactions; especially apt to cause trouble with animals with small stomachs, e. g., the horse.

Poor Quality: *e. g.*, hay cut too ripe or rained upon after cut, light oats, etc. Objections are the same as deficiency, also favors colic, impactions, and anæmia. A food may be poorly balanced and dangerous, though very nutritious; *e. g.*, beans, wheat, oil, meal, and cottonseed meal contain alone too much protein and not enough ash, fat, and carbohydrates. When fed in the unbalanced ration, such excess of protein may cause febrile disturbances, diarrhea, azoturia. Above all things, avoid feeding musty or moldy feeds. They are very frequent causes of disease of different kinds. Lung trouble, such as bronchitis and "heaves," often follows their use. The digestive organs always suffer from moldy or musty feeds.

Oats: No other grain is so dearly relished by the horse. Not only are oats palatable, but the nutriments they contain are in such proportion that this grain alone forms almost a balanced ration. The oat hull lightens up the feed, giving bulk and lessening possible errors in administering the ration too liberally. The digestive tract cannot hold such a quantity of oats as will ordinarily produce severe troubles from gorging. Care must be taken in selecting oats; the best oats are one year old, plump, short, hard, clean, light, and sweet. Moldy oats produce serious digestive disorders.

Wheat and Rye: These grains are not to be used for horses, except in small quantities, crushed, and mixed with other grains and hay. If fed alone, in very considerable quantities, it is almost certain to produce digestive disorders, laminitis (founder), and similar troubles. They should never constitute more than one fourth the grain allowance and should always be ground or crushed.

Corn: Although corn has not the qualities of oats it is the best heat-giving and fat-furnishing concentrate. It is better given ground and fed in quantities of from 1 to 2 quarts at a meal, mixed with crushed oats or wheat bran. Great care should be taken in giving corn to a horse that is not accustomed to its use. It must be commenced in small quantities and very gradually increased. There is no grain more liable to produce what is called acute indigestion than corn if these directions are not observed.

All By-Products of Milling should be fed mixed with hay dampened with water.

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Bran: The best grade of bran is of light weight with large clean flakes with an absence of foreign matter. It should be mixed with other concentrates to lighten ration or add bulk while improving its nutritive qualities. Supplied to horses once or twice a week in the form of a "mash" made with scalding water, bran proves a mild beneficial laxative. Hard-worked horses have neither time nor energy to digest feeds of much bulk, and hence their allowance of bran should be somewhat limited.

Linseed: Ground linseed is occasionally fed with other feeds to keep the bowels open and to improve the condition of the skin. Linseed tea is very often given in irritable or inflamed conditions of the digestive organs.

Potatoes: These are used as an article of feed for the horse in many sections. If fed raw in large quantities they often produce indigestion. Their digestibility is increased by steaming or boiling. They possess, in common with other roots, slight laxative properties.

Beets: These are not much used as feed for horses.

Carrots: Make a most excellent feed, particularly during sickness. They improve the appetite and slightly increase the action of the bowels and kidneys. They possess also certain alterative properties, making the coat smooth and glossy. The roots may be considered, then, as an adjunct to the regular regimen and, if fed in small quantities, are highly beneficial.

Cane Molasses: May be fed successfully by pouring the molasses on the hay, mixing a little bran with same to counteract constipation caused by molasses.

Grasses: Grass is the natural food of horses. It is composed of a great variety of plants, differing widely as to the amount of nutriment or nourishment contained, some being almost entirely without value and eaten only when nothing else is obtainable, while others are positively injurious, or even poisonous. None of the grasses are sufficient to keep the horse in condition for work. Horses thus fed are "soft," sweat easily, purge, and soon tire when on the road or when at hard work. Grass is indispensable to growing stock and there is little or no doubt that it acts as an alterative when given to horses accustomed to grain and hay. It must be given to such horses in small quantities at first. The stomach and intestines undergo rest and recuperate if the horse is turned to grass for a time each year. It is also certain that during febrile diseases, grass acts almost as a medicine, lessening the fever and favoring recovery. Wounds heal more rapidly than when the horse is on grain, and some chronic disorders (chronic cough, for instance) disappear entirely when at grass. Grass does more good when the horse crops it him-

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self. This may be due to the sense of freedom he enjoys at pasture, to the rest to his feet and limbs, and for many other similar reasons. When cut for him, it should be fed fresh or when but slightly wilted.

Hay: The best hay for horses is timothy. It should be about one year old, of a greenish color, crisp, clean, fresh, and possessing a sweet, pleasant aroma. Even this good hay, if kept too long, loses part of its nourishment and, while it may not be positively injurious, it is hard, dry, and indigestible. New hay is difficult to digest, produces much salivation (slobbering), and occasional purging and irritation of the skin. If fed at all, it should be mixed with old hay.

Straw: The straws are not fed to the army horse but are used as bedding. When used at all, they should be mixed with hay and cut and ground or crushed grain. Wheat, rye, and oat straws are the ones most used; of these, oat straw is most easily digested and contains the most nourishment. Pea and bean straw are occasionally fed to horses, the pea being preferable.

Chaff: Wheat and rye chaff should never be used as a feed for horses. The beards frequently become lodged in the mouth or throat and are productive of more or less serious trouble.

Oat Chaff: If fed in small quantities and mixed with cut hay or corn fodder, is very much relished by horses. It is not to be given in large quantities, a troublesome and sometimes fatal diarrhea following the practice of allowing horses free access to a pile of oat chaff.

Water: The water which a horse drinks passes almost immediately from his stomach into his small intestines and thence, in the course of a few minutes, to the cæcum or blind gut, which is the reservoir from which it is absorbed and used by the horse as needed. To water a thirsty horse immediately after he has eaten causes a considerable portion of the contents of his stomach to be carried with the water through the intestines; as a consequence, digestion is incomplete, there is avoidable loss of nourishment, and indigestion or colic may result. Animals can live much longer without solid food than without water and an insufficiency of water in the body causes serious disturbances. The processes of mastication, digestion, etc., are hindered, the intestines are not properly flushed, and waste water remains too long therein; the blood thickens; and the body temperature is increased. Through these complications, death may result. Horses partially deprived of water for a long period lose their appetite for solid food and diarrhea may occur. Water is an important regulator of the temperature of the animal body. It is generally held, at least in practice, that any water that horses can be induced to drink is sufficiently pure for their own use. This

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practice occasions losses that are easily avoided. Water is an important regulator of the temperature of the animal body. Water that is impure from the presence of decomposing organic matter, such as is found in wells and ponds in close proximity to manure heaps and cesspools, is frequently the cause of diarrhea, dysentery, and many other diseases of horses, while water that is impregnated with different poisons and contaminated in very many instances with specific media of contagion produces death. Considering first the quantity of water required by the horses, 5 to 15 gallons per day, it may be stated that when our animals have access to water continually, they never drink to excess. Were the horse subjected to ship voyages or any other circumstances, where he must depend upon the men for the supply of water, it may be roughly stated that he requires a daily average of about 8 gallons of water. This varies somewhat upon the character of his feed; if upon green grass, less water will be needed than when fed upon dry hay and grain.

The time of giving water should be carefully studied. At rest, the horse should receive at least three times a day; when at work, more frequently. The rule should be to give it in small quantities and often. There is a popular fallacy, that if the horse is warm, he should not be allowed to drink, many asserting that the first swallow of water "founders" the animal or produces colic. This is erroneous. No matter how warm a horse may be, it is always entirely safe to allow him from six to ten swallows of water. If this is going to be given upon entering the stable, he should have at once a pound or two of hay and allowed to rest about an hour before feeding. If water is now offered him, it will, in many cases be refused or at least he will drink but sparingly. The danger then is not in the first swallow of water, but is due to the excessive quantity that the animal will take when warm if he is not restrained.

Stabling

The horse spends about half of each day in the stable. Here he is subject to conditions of heat and cold over which he has no control. In order to keep him in good health he must have fresh air and plenty of it without the attendant danger of drafts.

The two purposes in ventilation are getting fresh air with its oxygen into a stable, and getting impurities out, and these are equally important.

Impurities: The common impurities of air, disease germs and their products; carbon dioxide gas, various volatile matters from the lungs, together with the various excretions and the products which result from their chemical decompositions.

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Necessity of Ventilation: To illustrate the effect of poor sanitary conditions, particularly lack of ventilation, it is only necessary to call attention to the common experience of moving an animal affected with a chronic type of glanders or tuberculosis from a well-lighted and well-ventilated stable to one where the conditions are the opposite. Under the latter conditions there is rapid development of a disease which had been mild. Sick animals especially need free ventilation. This is particularly true in certain diseases, *e. g.*, tetanus and diseases of the lungs and respiratory tract. A moderately warm stable in a cold climate is not objectionable, providing sanitary conditions, such as abundant air, sunlight, good food, and water, are provided. But making a stable warm and tight may very easily establish an ideal place for the propagation of germs and the spread of disease.

Natural Forces: The factors that operate in natural ventilation are:

1. The force of the wind.
2. Weight of air, as varied by its temperature.
3. Diffusion of gases in obedience to a natural law.

Wind: The force of the wind is probably the most important one of these factors, and must always be taken into consideration in planning ventilation. It is, of course, irregular, but variations can be made in the ventilating facilities to compensate for this. A fundamental point in using this factor is to see that the incoming air does not pass over or through any contaminating course, over a manure pile, or strike the body of the horse.

Temperature and Weight: The second factor, difference in weight between the lighter warm and heavier cold air, is not so important in natural as in artificial ventilation, and yet it is a factor of considerable importance. The heat which warms the air in the lower levels is that which comes from the bodies of confined animals as it is radiated from the surface or warmed in passing through the lungs.

Diffusion of Gases: Carbonic gas is considerably heavier than air, and the lower levels usually contain a slightly higher percentage than the higher ones in a stable, but the difference is not so great as one would suppose, on account of the diffusion which takes place in response to the law of diffusion of gases—which operates independently of relative weights. This force is so strong in its action that some diffusion takes place through unpainted lumber and through ordinary brick, but to a very slight extent if at all through painted surfaces or paper.

Amount of Ventilation Needed: The horse passes forty-five

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cubic feet of air through the lungs per hour. This, then, would be the amount which the average horse would use if he were out in the open where the supply is inexhaustible. It is impossible to have the air of any occupied stable as pure as the outside atmosphere. The purpose of ventilation is to come as near to this point as may be feasible. It has been estimated that the air should not be changed more than six times per hour in cool weather, on account of drafts which more frequent changes would produce, and the loss of animal heat.

Space Needed: A large cubic space per animal is important, but this does not lessen the necessity for ventilation. The atmosphere in a large stable with a given number of animals may become just as foul as a smaller stable with same number of animals, the only difference being in the length of time required to reach this condition. The chief value in a large amount of space is that it gives the possibility of admitting a sufficient amount of air without such severe drafts as would necessarily be the result of admitting the same amount of air per hour into a smaller stable.

Manure, soiled bedding, and refuse about the feed boxes and mangers should be removed daily and hauled to the dump. Feed boxes and mangers should be swept or brushed out daily, and once a week the feed boxes and a portion of the woodwork immediately surrounding them should be well scraped and washed clean with boiling water. The doors and windows should be kept open at all times, excepting during storms, and bales of hay or straw, and empty sacks or sacks filled with grain that may have become wet by rain blowing through open windows or doors, should be scattered about and allowed to dry. The corrals and picket lines should be swept daily, and special attention must be paid to the ground beneath the watering trough to see that it is kept clean and dry. If the floor of picket line should be of soft earth, it should be sprinkled once a week with crude oil.

Causes and Prevention of Disease

Definition: Living germs constitute the specific and primary cause of certain diseases and may be transmitted from one animal to another.

Description: Bacteria are vegetable microörganisms. Each individual consists of a single cell. They are of almost infinite number of species and varieties, and are present in the atmosphere in particles of room dust, in drinking water, in the soil, and, in fact, almost everywhere in great abundance.

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Size: They are extremely small, requiring the highest powers of the microscope to make them distinctly visible. It is estimated that millions may live comfortably in a single drop of fluid. An average bacillus is from 1–25,000 to 2–25,000 of an inch long.

Nutrition: Bacteria use for their food a compound formed from the chemical elements, oxygen, nitrogen, carbon, hydrogen, phosphorus, and sulphur. Like higher beings, they vary in their likes and dislikes. What is wholesome for one may be very injurious to another. Each species has its certain conditions of moisture, temperature, and chemical reaction which are most favorable.

How Scattered.—Germs of diseases are scattered by a very great many agencies. Germs are disseminated by means of diseased carcasses, stock cars, and they may be easily transferred by the shoes or clothing of persons who walk through an infected area. Dogs undoubtedly serve to scatter diseases over wide areas, and possibly birds. It is possible also for the germs to be scattered by particles of dust and litter in high winds. Watering troughs, tanks, ponds, and sluggish streams are all common courses for spreading infectious diseases.

Development of Outbreaks: It seems to be true of several, and possibly so of a great many of diseases, that the germs may be present with the animal or his surroundings but not virulent enough to produce disease. Under favorable conditions and perhaps after passing through the bodies of several susceptible animals in succession they may increase in virulence sufficiently to produce disease.

Some of the germs producing diseases of domestic animals are believed to live for very long periods of time and even vegetate outside the animal body, possibly upon or within the tissues of plants. Some germs, especially in the resting or spore stage, may live for very long periods of time, and under very unfavorable conditions and retain virulence.

Some outbreaks of infectious diseases appear very suddenly, with the most virulent and rapidly fatal cases appearing earliest in the outbreak. The outbreak then gradually loses virulence, the last cases being of a decidedly chronic nature, and some of them possibly recovering. It is possible, however, that, before the virulent form was noticed, there may have been a series of very mild cases, the animals not being appreciably sick; but the germs in passing through susceptible bodies greatly increased in virulence until they were able to produce a rapidly fatal type of the disease.

Body Entrance: Germs gain entrance through the respiratory organs with the inspired air; through the digestive organs; through cuts or scratches in the skin and mucous membranes.

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Method of Injury: Germs cause injury and disease in at least two different ways: First, by rapid multiplication and direct attack in inconceivable numbers upon the tissue. As an example of condition caused by germs in this way, we have fistulous withers. Second, germs which by chemical action may produce intensely poisonous substances in the blood and body tissues. As an example of this we have tetanus.

How Disposed of in Nature: Nature disposes of disease germs in a variety of ways, principally by oxidation, by the devitalizing effect of sunlight, and by scattering them over wide areas by means of wind and water.

Bacteria or germs usually require very favorable conditions for existence, and especially for retaining disease-producing power. Make conditions unfavorable for them by vigorous health, by high resisting power on the part of the animal, and by sunshine and ventilation. Bear in mind that germs are actual substances, tiny particles of living matter, and may be carried about in any way that very fine particles of dust may be scattered.

The beginning of an outbreak may come in two ways: First, by recent introduction of germs; or, second, an outbreak of infectious disease may be caused by increased virulence in case of germs already present, but not previously capable of producing disease. This increase of virulence may be due to surrounding conditions especially favorable to germ life.

Apparently it makes great difference in many diseases as to the number of germs taken into the body,—hence the necessity of sunshine to reduce virulence and destroy germs and of ventilation to carry as many of them as possible out into the open air.

Disinfection and Common Disinfectants

Causes of Infection: In any process of disinfection it is important to know something concerning the nature of the infecting germ and the sources from which it comes. Germs of diseases are spread in a great variety of ways; for instance, with the body fluids of sick animals, by soiled water or food, or by any contaminated matter. Air may be contaminated from the skin and lungs of diseased animals. The soil may be contaminated by the burial of diseased animals or by the deposit of any infectious material upon the surface. In any such case, germs may be washed to ponds, sluggish streams, or shallow wells, thus contaminating the water. Hides, offal, and even the hair of a diseased animal may be the source of spreading disease.

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Bearing in mind now what has been said of germs, it is easy to see how glanders with infection left in feed boxes or water pails may be spread from horse to horse; diseases with infection, especially in the manure, may be easily and rapidly spread; or how diseases may be spread by germs in the pus scattered from abscesses.

Must Be Thorough: Disinfection is not reliable and should not be depended upon unless done most thoroughly. A small area may be disinfected by having straw burned over it, or the earth may be removed to a depth of at least four inches and replaced with fresh earth. Paved flooring may be disinfected by burning over it any inflammable material. Cracks should be disinfected by free use of corrosive sublimate solution. Food which may have been contaminated should ordinarily be destroyed. Drinking places, feed boxes and mangers are cleaned and disinfected. Manure and bedding must be removed, piled up on the outside, and burned. All the equipment—bridles, halters, harness, blanket, grooming utensils, attendants' clothing, forks, brooms, etc.,—should be washed with soap and water, then scrubbed with a disinfectant. **Do not use bichloride of mercury** as a disinfectant on bits, curb-chains, etc., as it will corrode them.

Attendants: Attendants for sick animals should be very careful about their clothing, particularly trousers and shoes. It is well to use special overalls and overshoes, which should be left at the infected stall or building. Dogs, rats, and any of the smaller animals which are liable to convey the disease should be guarded against.

Fire: The most reliable disinfectant, and the one that should invariably be used when an article is to be destroyed.

How to Burn a Carcass: Dig a cross-shaped trench, about twelve inches deep in the center, becoming shallow toward the edges, about seven feet long each way. The earth is thrown in the angles; two bars of iron are placed across for a bridge, and upon them the fuel is placed. The trunk of the carcass is placed upon the fuel, then another layer of fuel, then the internal organs and limbs of the carcass, and finally another layer of wood. The cross-shaped trench gives a draft—no matter which way the wind may be blowing.

By Burying: When burning is impracticable, carcasses should be buried. The grave should be at least eight feet deep and the carcass should be well covered with unslacked lime, after which the grave is filled in and the earth well packed. Earth which has been soiled by blood, manure, nasal discharges, etc., should be scraped up and thrown into the bottom of the grave. Wagons, etc., in which animals dead of contagious disease are hauled, should be cleaned and disinfected.

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Moist Heat: More active and reliable than dry heat at same temperature. Boiling for an hour is probably sufficient to destroy any known disease-producing germs.

Sunshine: Destroys germs. Whenever sufficient time may be had, infected clothing or any article to be disinfected, especially where the infection is on the surface, can be rendered safe by long exposure to sunshine. The germs of some diseases cannot lurk and reproduce in sunlight or in the presence of oxygen, but do so indefinitely in dark, damp places.

Chemical: There are a number of chemical agents that are frequently used and most of them are coal-tar products. These are supplied by the veterinary with directions for using same.

Isolation: Is a preventive measure wherein an animal affected with contagious disease, or one suspected of such a disease, is separated from the healthy animals and placed by itself.

Each isolated animal must be provided with a separate feed box, water bucket, blanket, and grooming outfit, none of which should be removed from the place of isolation until properly disinfected. Attendants should have no duties which bring them in contact with other animals. No animal carcass, forage, bedding, or manure should be removed from the place of isolation without proper authority. Immediately after an animal has been removed from the place of isolation, his entire equipment, watering bucket, feed box, etc., should be disinfected.

Common Diseases, Wounds, and Lameness

In control of infectious diseases, prevention is the most important procedure. The isolation of healthy animals from infected animals should be primarily considered, and if at any time an animal shows the symptoms of an infectious disease it is essential to protect the others from such a source of danger. In some of the infectious diseases it is or may become advisable to kill the infected animals in order to avoid the spread of the disease.

Influenza

The term influenza is applied to a contagious disease of horses, which is characterized by a blood infection, causing inflammation of the mucous membranes and frequently involving the lungs.

In order to prevent the introduction of the disease it is advisable to isolate animals that are issued to organizations for at least one week. Furthermore, the stabling of healthy horses in feed stables

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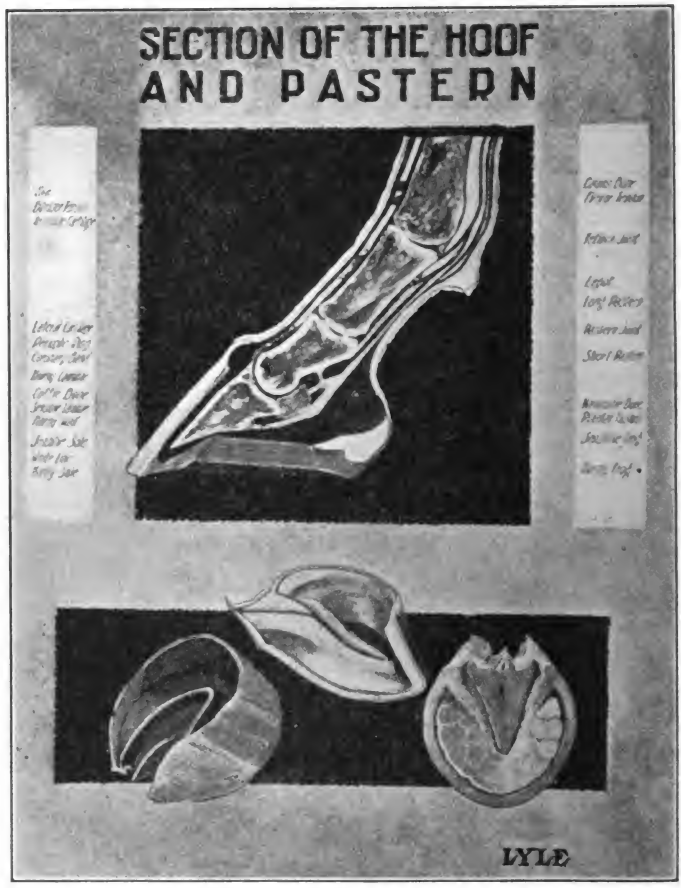
should be guarded against. At the beginning of an outbreak the disease may be checked by immediate isolation of the infected horses, and later by the segregation of those showing a marked increase in temperature. Contagious pneumonia is an acute inflam-



mation of the lungs. The same procedure as given for influenza should be carried out in the prevention of this infection.

Glanders and Farcy

Let it be understood at the outset that the glanders and farcy are one and the same disease, differing only in that the first term is usually applied to the disease when the local lesions predominate in the internal organs, especially in the nostrils, lungs, and air tubes, and that the second term is applied to it when the principal manifes-

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tation is an outbreak of the lesions on the exterior or skin of the animal. The term glanders is sometimes applied to the disease in both forms, while the term farcy is limited to the visible appearance of the external troubles only; but in the latter case internal lesions always exist, although they may not be evident. It is characterized by the formation of nodules of connective tissue which degenerate into ulcers, from which exudes a peculiar discharge.

Thick Wind and Roaring

Horses affected with a chronic disease that causes a loud unnatural noise in breathing are said to have thick wind, or to be roarers. Their class does not include those affected with severe sore throat, as in these cases the breathing is noisy only during the attack of the acute disease. Thick wind is caused by an obstruction to the free passage of the air in some part of the respiratory tract.

The comfort and surrounding of the patient must be attended to first. The quarters should be the best that can be provided. Pure air is essential. Avoid placing the animal in a stall where he may be exposed to drafts of cold air and sudden changes of temperature. It is much better for the animal if the air is cold and pure than if it is warm and foul. It is better to make the animal comfortable with warm clothing than to make the stable warm by shutting off the ventilation. From the start the animal should have an unlimited supply of fresh cold drinking water. Blanket the body.

Heaves, Broken Wind

Heaves is usually associated with digestive disorders or to an error in the choice of feed. Feeding on clover hay or damaged hay or straw, too bulky and innutrious feed, and keeping the horse in a dusty atmosphere or a badly ventilated stable produce or predispose heaves. Horses brought from a high to a low level are predisposed. When the disease is established there is no cure for it.

Proper attention paid to the diet will relieve the distressing symptoms to a certain extent, but they will undoubtedly reappear intensified the first time the animal overloads the stomach or is allowed food of poor quality. Clover hay or bulky feed which contains but little nutriment is a common cause of the disease, and therefore should be entirely omitted from the diet. It has been asserted that the disease is unknown where clover hay is never used. The diet should be confined to feed of the best quality and in the

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smallest quantity. The bad effect of moldy or dusty hay, fodder, or feed of any kind cannot be overestimated. A small quantity of the best hay once a day is sufficient. This should be cut and dampened. The animal should be watered before feeding; never directly after a meal. Exertion when the stomach is full invariably aggravates the symptoms.

Meningitis, Cerebritis

Exposure to extreme heat or cold, sudden and extreme changes of temperature, excessive continued cerebral excitement, too much nitrogenous feed, direct injuries to the brain, such as concussion, or from fracture of the cranium, over exertion, sometimes sequel to influenza, pyemia, poisons having a direct influence upon the encephalic mass, extension of inflammation from neighboring structures, food poisoning, tumors, parasites, metastic abscesses, etc.

Tetanus, or Lockjaw

This disease is characterized by spasms affecting the muscles of the face, neck, body, and limbs and of all muscles supplied by the cerebrospinal nervous system. The spasms or muscular contractions are rigid and persistent, yet mixed with occasional convulsions.

This disease is caused by a bacillus that is often found in dust. This germ forms spores which grow only in the absence of oxygen. It produces a powerful nerve poison, which causes the symptoms of tetanus. The germ itself multiplies at the first point where it is introduced, but its poison is absorbed and is carried by the blood to all parts of the body, and thus the whole nervous system is poisoned. Deep wounds infected by this germ are more dangerous than superficial wounds, because in them the germ is more remote from the oxygen of the air. Hence, nail pricks, etc., are especially dangerous. In the majority of instances the cause of tetanus can be traced to wounds, especially pricks and wounds of the feet or of the tendinous structures. It sometimes follows castration, docking, the introduction of setons, inclusion of a nerve in a ligature, etc. It may break out three or four months after the wound is healed. Horses with a nervous excitable disposition are predisposed to infection.

When a valuable horse has sustained a wound that it is feared may be followed by tetanus, it is well to administer a dose of tetanus antitoxin. This is injected beneath the skin with a hypodermic syringe. A very high degree of protection may in this way be afforded. This antitoxin should be administered by a veterinarian.

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Laminitis

Laminitis is a simple inflammation of the sensitive laminæ of the feet. Causes of laminitis are many and varied. The most common are concussion, overexertion, exhaustion, and rapid changes of temperature. (First) Concussion produces this disease by local overstimulation. (Second) Overexertion, as heavy pulling or rapid work, even when there is no immoderate concussion, occasionally results in this disease. (Third) Exhaustion causes those cases where the disease follows a hard day's work, physical strength being impaired. (Fourth) Rapid changes of temperature are exciting causes of laminitis by impairing the normal blood supply. (Fifth) Certain kinds of grain will cause laminitis, though the reason does not seem to be clearly understood.

Azoturia

A disease of the liver and blood-forming organs, with a loss of control of the hind limbs and the passage of soapy and dark-colored urine. It is directly connected with high feeding, especially on highly nitrogenous feed (oats, peas, etc.), followed by idleness in the stall.

Restrict diet and give daily exercise when the animal is not at work. A horse that has had one attack should not be left idle for a single day in the stall or on the picket line.

Lymphangitis

Specific inflammation of the lymphatic structures usually affecting the hind legs; very seldom a fore leg.

Usually attacks well-fed animals, and in such cases may be due to an excess of nutritive elements in the blood. Sudden changes in work or in habits of the animal may induce an attack. Prevention same as in azoturia.

Colic

An excessive accumulation of gas in stomach, contraction of small intestines, sand in stomach and small intestines, or infection of the large intestines.

Sudden changes of feed, too long fasting, feeding while animal is exhausted, and giving feed that has been in the manger for some time and become sour; anything that produces indigestion, such as

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watering when the animal is warm, driving a heated horse through streams, and feeding on sandy picket lines.

Lameness

Usually the discovery that the animal is becoming lame is a comparatively easy matter to the careful observer. Such a person will readily note any changes in movements which will have taken place in the animal he has been accustomed to ride or drive, unless they are very slight. But what is not always so easy, to learn after having discovered the fact of an existing irregularity, is the locality of its point of origin, and whether its seat be in the near or off leg, in the fore or hind leg, or some other part of the body. These are questions too often wrongly decided, notwithstanding the fact that with a little careful scrutiny the point may be easily settled. The error, which is too often committed, of pronouncing the leg upon which the animal travels soundly as the seat of the lameness, is the result of a misinterpretation of the physiology of locomotion in the crippled animal. Much depends upon the gait with which the animal moves while under examination. The act of walking is unfavorable for making an accurate observation, though the decision is easy to reach if the animal walks on three legs. The action of galloping will often, by the rapidity of the muscular movements and their quick succession, interfere with an accurate study of their rhythm, and it is only under some peculiar circumstances that the examination can be safely conducted while the animal is moving with that gait. It is while the animal is trotting that the investigation is made with the best chances of an intelligent decision, and it is while moving with that gait, therefore, that the points should be looked for which must form the elements of the diagnosis. The causes for lameness are taken up in Instruction Memorandum No. 17-G. on Soundness.

Wounds

A wound is an injury to any part of the body caused by violence, with or without laceration of the skin. An accidental wound is a simple cut made with a sharp instrument, such as a knife, producing merely a division of the tissue. In a cut wound the edges are even and definite, while those of a lacerated wound are irregular and torn. The checking of the flow of blood may be accomplished by several methods, such as compress bandages, hot iron, and ligatures. The heat from a hot iron will cause the immediate clotting of the blood

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in the vessels and this clot is further supported by the production of a scab, or crust, over the portion seared. The iron should be at a red heat. If at a white heat the tissue is charred, which makes it brittle and the bleeding is liable to be renewed. If iron is at a black heat, the tissue will stick to the iron, and will pull away from the surface of the wound. Cold water and ice bags will quickly stop capillary bleeding, while hot water is preferable in more excessive bleedings or hemorrhages. Some drugs, called styptics, possess the power of contracting the walls of blood vessels and also of clotting the blood. A solution of chloride of iron placed on the wound alone or by means of cotton drenched in the liquid produces a rapid and hard clot. Tannic acid, alum, acetic acid, alcohol, and oil of turpentine are all more or less active in this respect. To check rapid and dangerous bleeding from large vessels compression may be adopted. When it is from an artery, the fingers may be used for pressing between the wound and the heart, but if from a vein, the pressure should be exerted on the other side of the wound.

Bruises: Are nothing but wounds where the skin has not been ruptured.

Punctured Wounds: Are produced by the penetration of a sharp or blunt-pointed instrument, such as a thorn, fork, nail, etc., and the orifice of these wounds is always small in proportion to their depth. In veterinary practice punctured wounds are very much more common than the others. They involve the feet most frequently, next the legs, and often the face and head from nails protruding through the stalls and trough. They are not only the most frequent, but they are also the most serious, owing to the difficulty in obtaining thorough disinfection. Another circumstance rendering them serious is the lack of attention that they receive at first. The external wound is so small that but little or no importance is attached to it, yet in a short time swelling, pain, and acute inflammation, often of a serious character, are manifested. Considering the most common of puncture wounds, we must give precedence to those of the feet. The animal treads upon nails, pieces of iron or screws, forcing them into the soles of the feet. If the nail or whatever it is that has punctured the foot is attached to some heavier body and is withdrawn as the horse lifts his foot, lameness may last for a few steps only, but, unless properly attended to at once, the horse will be found in a day or two to be very lame in the injured member. If the foreign body remains in the foot, he gradually grows worse until the cause is discovered and removed.

From the construction of the horse's feet and from the elasticity of the horn closing the orifice, punctured wounds of the feet are

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almost always productive of lameness. Inflammation results, and, as there is no relief afforded by swelling and no escape for the product of inflammation, this matter must and does burrow between the sole or wall and the sensitive parts within it until it generally opens "between hair and hoof." From the fact that the pain is so much more severe, and that tetanus more frequently follows wounds in the feet, and from the extensive, or at times complete, separation and "casting" of the hoof, these wounds must always be regarded with grave apprehension.

The practice of picking up each foot, cleaning the sole, and thoroughly examining the foot each and every time the horse comes into the stable will enable us to reduce to the minimum the serious consequences of punctured wounds of the feet. If the wound has resulted from pricking, lameness follows soon after shoeing; if from the nails being driven too close, it usually appears from four to five days or a week afterward. We should always inquire as to the time of shoeing, examine the shoe carefully, and see whether it has been partially pulled and the horse has stepped back upon some nails or the clip. The horse is seen to raise and lower the limb or hold it from the ground altogether; often he points the foot, flexes the leg, and knuckles at the fetlock. Swelling of the fetlock and back tendons is also frequently seen and is liable to mislead us. The foot must be carefully examined, and this cannot be properly done without removing the shoe. The nails should be drawn separately and carefully examined. If there is no escape of pus from the nail holes, or if the nails themselves are not moist, we must continue our examination of the foot by carefully pinching or tapping it at all parts. With a little practice we can detect the spot where the pain is the greatest or discover the delicate line or scar left at the point of entrance of the foreign body.

Punctured Wounds of Joints, or Open Joints: These wounds are more or less frequent. They are always serious, and often result in anchylosis of the joint or the death of the animal. The joints mostly punctured are the hock, fetlock, or knee, though other joints may, of course, suffer this injury. Probably the most common injury is the stab from the fork, but it may result from the kick of another horse that is newly shod, or in many other ways.

Gunshot Wounds: Vary in size and character, depending on the size and quality of the projectile and also the tissue injured. Oftentimes a ball may be so lodged that it cannot be removed, and it then may become encysted and remain for years without giving rise to any inconvenience. It is often difficult to locate a bullet, as it is very readily deflected by resistance met with after entering the body.

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The entering wound is the size of the projectile, the edges being inverted and often scorched. The wound produced in case of the bullet's exit is larger than the projectile, the edges are turned out and ragged. A bullet heated by the friction of the barrel or air often softens and becomes flattened on striking a bone or other tissue. Modern bullets that have an outer steel layer may pass through bone without splintering it. Lead bullets may split, producing two exit wounds. Spent bullets may only produce a bruise. Should bones be struck by a ball they are sometimes shattered and splintered to such an extent as to warrant us in having the animal destroyed. A gunshot wound, when irreparable injury has not been done, is to be treated the same as punctured wounds, *i. e.*, stop the hemorrhage, remove the foreign body if possible, and apply hot fomentations or poultices to the wound until suppuration is fairly established. Antiseptic and disinfectant injections may then be used. Should pus accumulate in the tissue, openings must be made for its escape.

Harness Galls are wounds of the skin frequently caused by ill-fitting harness or saddles. When a horse has been resting from steady work for some time, particularly after being idle in a stable on a scanty allowance of grain, as in winter, he will be soft and tender and will sweat easily when put to work again. In this condition he is liable to sweat and chafe under the harness, especially if it is hard and poorly fitted. This chafing is likely to cause abrasions of the skin, and thus pave the way for an abscess or for a chronic blemish, unless attended to very promptly. Besides causing the animal considerable pain, chafing, if long continued, leads to the formation of a callosity. This may be superficial, involving only the skin, or it may be deepened, involving the subcutaneous fibrous tissue and sometimes the muscles and even the bone. This causes a dry slough to form, which is both inconvenient and unsightly. Sloughs of this kind are commonly called "sitfasts" and, while they occur in other places, are most frequently found under the saddle.

Abrasions are best prevented by bringing the animal gradually into working shape after it has had a prolonged rest, that the muscles may be hard and the skin tough. The harness should be well fitted, neither too large nor too small, and it should be cleaned and well oiled to remove all dirt and make it as pliable as possible. Saddles should be properly fitted so as to prevent direct pressure on the spine and the saddle blankets should be clean and dry. Parts of the horse where chafing is likely to occur, as on the back under the saddle, should be cleaned and brushed free of dirt. The remedies for simple harness galls are numerous. Among them may be mentioned, alcohol: one pint, in which are shaken the whites of two eggs; a solution of

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nitrate of silver, ten grains to the ounce of water; sugar of lead or sulphate of zinc, twenty grains to an ounce of water; carbolic acid, one part in fifteen parts of glycerin; and so on almost without end. Any simple astringent or powder will effect a cure, provided the sores are not irritated by friction. If a sitfast has developed, the dead hornlike slough must be carefully dissected out and the wound treated carefully with antiseptics. During treatment it is always best to allow the animal to rest but if this is inconvenient, care should be taken to prevent injury to the abraded or wounded surface by padding the harness so that the chafing cannot occur.

Fistulas: This word is applied to any ulcerous lesion upon the external surface of the body which is connected by ducts, or passages with some internal cavity. Because of this particular formation the term fistulous tract is often used synonymously with the word fistula. Fistula may exist in any part of the body, but the name has come to be commonly accepted as applicable only to such lesions when found upon the withers. Poll-evil is a fistula upon the poll, and in no sense differs from fistulous withers except in location. The description of fistula will apply, then, in the main, to poll-evil equally well. Quittor presents the characteristic tubular passages of a fistula and may, therefore, be considered and treated as fistula of the foot.

Cracked Heels (Scratches or Chaps on Knee and Hock): This usually sets in with swelling, heat, and tenderness of the hollow of the heel, with erections of the hair and redness (in white skins), with stiffness and lameness, which may be extreme in irritable horses. Soon slight cracks appear transversely and may gain in depth and width and may even suppurate. More frequently they become covered at the edges or throughout by firm incrustations resulting from the drying of the liquids thrown out, and the skin becomes increasingly thick and rigid. A similar condition occurs behind the knee and in front of the hock, and may extend from these points to the hoof, virtually incasing that side of the limb in a permanent incrusting sheath.

Causes: Besides a heavy lymphatic constitution, which predisposes to this affection, the causes are overfeeding on grain, unwholesome fodder, close, hot, dirty stables, constant contact with manure or urine and their emanations, working in deep irritant mud: above all, in limestone districts, irritations by dry limestones or sandy dust in dry weather on dirt roads; also cold drafts, snow and freezing mud, washing the legs with caustic soap, wrapping the wet legs in thick woolen bandages which soak the skin and render it sensitive when exposed next day, clipping the heels, weak heart and

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circulation, natural or supervening on overwork, imperfect nourishment, impure air, lack of sunshine, chronic exhaustion, or debilitating disease, or functional or structural diseases of the heart, liver, or kidneys. These last induce dropsical swelling of the limbs (stocking), weaken the parts, and induce cracking. Finally the scar of a preëxisting crack, weak, rigid and unyielding, is liable to reopen under any severe exertion; hence rapid paces and heavy draft are active causes.

Warts: These are essentially an overgrowth of the superficial layer of the skin. They are mostly seen in young horses about the lips, eyelids, cheeks, ears, beneath the belly, and on the sheath, but may develop anywhere. The smaller ones may be clipped off with scissors and the raw surface cauterized with bluestone. The larger may be sliced off with a sharp knife, or if with a narrow neck they may be twisted off and then cauterized. If very vascular they may be strangled by a wax thread or cord tied around their necks, at least three turns being made around and the ends being fixed by passing them beneath the last preceding turn of the cord, so that they can be tightened day by day as they slacken by shrinkage of the tissue. Very broad warts that cannot be treated in this way may be burned down with a soldering bolt at a red heat to beneath the surface of the skin, and any subsequent tendency to overgrowth kept down by bluestone.

Vegetable Parasites of the Skin—Ringworm: This is especially common in young horses coming into training and work. In the horse the symptoms are the formation of circular, scurfy patch where the fungus has established itself, the hairs of the affected spot being erect, bristly, twisted, broken, or split up, and dropping off. Later the spot first affected has become entirely bald, and a circular row of hairs around this are erect, bristly, broken, and split. These in turn are shed and a new row outside passes through the same process, so that the extension is made in more or less circular outline. The central bald spot, covered with a grayish scurf and surrounded by a circle of broken and split hairs, is characteristic. The eruption usually appears on the back, loins, croup, chest, and head.

The most effective way of reaching the parasite in the hair follicles is to extract the hairs individually, but in the horse the mere shaving of the affected part is usually enough. It may then be painted with tincture of iodine twice a day for two weeks. Germs about the stable may be covered up or destroyed by a whitewash of freely burned quicklime, the harness, brushes, etc., may be washed with caustic soda and then smeared with a solution of corrosive sublimate one half dram and water one pint.

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Another parasite which attacks the horse's head where the harness presses, leads to the dropping of the hair, leaving bald patches covered with a bran-like scurf, without any eruption, heat, tenderness, swelling, or rigidity of the skin. A lotion of carbolic acid one dram and water 2½ ounces is usually applied to effect a cure.

Animal Parasites of the Skin—Mange: The mite is nearly microscopical, but may be detected with a magnifying lens among moving scurf taken from the infected skin. It burrows little galleries in and beneath the scurf skin, where it hides and lays its eggs and where its young are hatched. It is therefore often difficult to find the parasite on the surface, unless the skin has been heated by a temporary exposure to the sun or in a warm room.

Symptoms.—The symptoms are an incessant, intolerable, and increasing itching of some part of the skin (head, mane, tail, back, etc.), the horse inclining himself toward the hand that scratches him and moving his lips as if himself scratching. The hairs may be broken and rubbed off, but the part is never entirely bald as in ringworm, and there may be papules or any kind of eruption or open sores from the energy of the scratching. Scabs of any thickness may form but the special features are the intense itching and the presence of the parasite.

Treatment consists in dipping the horses and a dipping vat is usually at every remount station for this purpose and, if necessary, a brush and a thorough application of tobacco 1½ ounces and water 2 pints, prepared by boiling.

Common Medicines, Action, Uses, and Methods of Administration

Definitions

Antiseptics: Agents used on or in the body in the treatments of wounds or diseases which prevent the growth and development of germs. Example: Carbonic acid, bichloride of mercury, iodine, creolin, etc.

Astringents: Agents which contract tissues and check secretions. Example: Alum, zinc, tannic acid, etc.

Carminatives: Agents which aid in the expulsion of gas from the stomach and intestines. Example: Ginger, turpentine, aromatic spirits of ammonia.

Disinfectants: Agents which destroy the germs that cause infectious diseases. Example: Chloride of lime, carbolic acid, creolin, formalin.

Deodorants: Agents which disguise or destroy odors. Example: Creolin, carbolic acid.

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Laxatives: Mild cathartics. Example: Small doses of oil, bran mash, green foods.

Purgatives: (Cathartics).—Agents which empty the bowels. Example: Aloes, salts, and linseed oil.

Parasiticides: Agents which kill animal and vegetable parasites infesting the skin. Example: Carbolic acid, creolin, salicylic acid.

Stimulants: Agents which promptly but temporarily increase nervous vigor. Example: Alcohol, aromatic spirits of ammonia, ether.

Styptic: Agents which check hemorrhage. Example: Tincture of iron.

Common Medicines

Aloes Barbados: Purgative dose, six to eight drams. This is a slow but powerful-acting cathartic taking about twenty-four hours to operate. Of value whenever an active purge is desired. May be given in the form of a ball or in solution in hot water. It should not be given when there is great weakness, a tendency to diarrhea, or in respiratory diseases. Ginger is generally given with aloes to overcome the griping which it causes.

Ammonia, Aromatic Spirits: Stimulant and carminative. Dose one to two ounces diluted with pint of water. Of great value in exhaustion, and in the treatment of colics.

Charcoal: A mild antiseptic and deodorant. Used as a dry dressing for foul-smelling wounds, either alone or in combination with other drugs.

Acid, Boracic (Boric Acid): Non-irritant antiseptic. Used in all strengths up to a saturated solution as a mild soothing antiseptic in diseases of the eyes, and as a wet or dry dressing for wounds. Also in the form of an ointment for burns, etc. Strength: ten per cent. or in combination with other drugs.

Acid, Tannic—Astringent: Dose: one half to two drams. Used internally in the treatment of diarrhea and dysentery, given alone or in combination with other drugs. Externally it is used to check bleeding from raw surfaces. In solution with alcohol or witch hazel, it may be used to harden tender shoulders. It is also useful in the form of an ointment, one to four, for scratches, etc.

Formalin: Antiseptic, disinfectant, and deodorant. Used externally only. It is very irritating and should not be used stronger than one dram to a quart of water approximately one two hundredth for ordinary purposes.

Iodine: Disinfectant and antiseptic. Used externally, iodine is a powerful antiseptic. Either the tincture or the solution is valuable

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in the treatment of wounds, sores, ulcers, curles, splints, enlarged tendons, etc. For such purpose it must be applied once or twice daily with a small cotton swab.

Lead Acetate of Sugar (Sugar of Lead): Astringent. Used externally in the form of white lotion for its cooling and soothing action in the treatment of sprains, bruises, itching skin disease, cuts, burns, and scratches. All local conditions with heat, pain and swelling are benefited by its use. White lotion is made as follows:

Lead	One ounce.
Zinc sulphate	One "
Water to make	One quart.

Shake well and apply twice daily.

Lime, Chloride of: Disinfectant and deodorant. Must be fresh and kept in sealed jars. Use six ounces to the gallon of water to disinfect stables.

Oil, Linseed: Laxative. Dose one to two pints. Much used in treatments of colics. Raw oil should always be used.

Oil, Turpentine: Stimulant, antiseptic, carminative, and vermicide. Dose one to two ounces, well diluted with oil. This is a most useful drug and of great value in the treatment of colics, especially flatulent colics. Used externally in stimulating liniments and to disinfect nail wounds. Given as an inhalation in respiratory diseases, one to two ounces in a pint of boiling water.

Potassium Permanganate: Antiseptic, disinfectant, and deodorant. Used externally as an antiseptic in the treatment of wounds, one to two drams to a pint of water. Full strength is mildly caustic.

Epsom Salts: Causes a large secretion of fluids from the intestinal walls, thus rendering the bowel contents very fluid. Epsom salts is useful in small doses given to horses in feverish condition. Will dissolve in its own weight of water.

Soap, Castile: A cleaning agent used in removing grease and dirt from the skin surrounding the margin of wounds. Should not be applied to raw surfaces. Also used in making soap liniment.

Zinc Sulphate: Antiseptic and astringent. Used externally in the form of white lotion, for the treatment of bruises, collar sores, sore shoulders, saddle sores, etc.

Bandages

Flannel: Use chiefly on the legs for warmth, support, protection.

Cotton: Used for the retention of bandages and the protection of wounds.

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Zinc Oxide: Mildly astringent and antiseptic. Used as a dry dressing for wounds, either alone or in combination with other drugs.

Dressings

Absorbent Cotton: Used as a substitute for sponges in the cleaning of wounds; to make packs by soaking in medical solutions; and to retain dry dressings in contact with the surface of wounds.

Antiseptic Gauze: A light, loosely woven variety of cloth which has been saturated with an antiseptic and dried. Used as a covering for wounds. Gauze must be kept clean and the part that is to come in contact with the wound should never be touched with the fingers or hands.

Oakum; Prepared fiber from old ropes. Used principally in packing horses' feet. It may also be used as a substitute for sponges, and in the absence of cotton and gauze as a covering for wounds.

Packs: Packs are made by soaking cotton gauze, oakum, or similar material in hot or cold medical solutions, after which they are applied to the part with a bandage.

Poultices: Poultices are a preparation for the local application of heat and moisture. They are made usually of flaxseed meal and bran, but other substances, such as oatmeal and bread, may be used. The material from which they are to be made is stirred up in hot water until thick and pasty. This mass is then spread on a piece of sacking or cloth of any kind and applied while hot, directly to the part and held by bandages or other appliances. When poultices are intended for use on wounds, such as punctures of the foot, etc., from two to four drams of carbolic acid or creolin should be added to the mass to render it antiseptic.

Poultices are most useful about the feet. They should be changed twice daily and immersed in hot water to keep them fresh and to prevent drying. Their application should not be continued for more than three or four days at a time.

Methods of Administering Medicines

By the Mouth: Medicines can be given by the mouth in the form of solids, as powders or pills, liquids and pastes, or electuaries.

Powders: Solids administered as powders should be as finely pulverized as possible, in order to obtain rapid solution and absorption. Their action is in this way facilitated and intensified. Those that are without any disagreeable taste or smell are readily eaten with the feed or taken in the drinking water. When placed with the

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feed they should first be dissolved or suspended in water and thus sprinkled on the food. If mixed dry, the horse will often leave the medicine in the bottom of his manger.

Balls are preferred to drenches when the medicine is extremely disagreeable or nauseating; when the dose is not too large; when the horse is difficult to drench or when the medicine is intended to act slowly. Always loose the horse before attempting to give a ball; if tied, he may break his halter and injure himself or the one giving the ball.

The tongue must be firmly grasped with the left hand and gently pulled forward; the ball, slightly moistened, is then to be placed with the tips of the fingers of the right hand as far back in the mouth as possible. As the tongue is loosened it is drawn back into the mouth and carries the ball backward with it.

The mouth should be kept closed for a minute or two. We should always have a pail of water at hand to offer the horse after balling. This precaution will often prevent him from coughing up the ball or its becoming lodged in the gullet.

Pastes: They are intended, chiefly, to act locally upon the mouth and throat. They are given by being spread upon the tongue, gums, or teeth with a wooden paddle or strong, long-handled spoon.

Liquids: Liquids may be given as drenches when the dose is large, or they may, when but a small quantity is administered, be injected into the mouth with a hard rubber syringe or be poured upon the tongue from a small vial. When medicine is to be given as a drench we must be careful to use water or oil enough to dissolve or dilute it thoroughly. Insoluble medicine, if not irritant or corrosive, may be given simply suspended in water, the bottom to be well shaken immediately before giving the drench.

The bottle used for drenching purposes should be clean, strong, and smooth about its neck; it should be without shoulders, tapering, and of a size to suit the amount given.

If the dose is a small one the horse's head may be held up by the left hand, while the medicine is poured into the mouth by the right. The left thumb is to be placed in the angle of the lower jaw, and the fingers spread out in such a manner as to support the lower lip. Should the dose be large and the attendant unable to support the head as directed above, the halter strap or rope may be fastened to the nose band and thrown over a limb or beam. Another way of supporting the head is to place a loop in the end of a rope and introduce this loop into the mouth just behind the upper front teeth or tusk of the lower jaw, the free end to be run through a pulley, as before described, and held by an assistant. It is never to be fastened,

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as the horse might in that case do himself serious injury. The head is to be elevated just enough to prevent the horse from throwing the liquid out of the mouth. The line of the face should be horizontal or only the least bit higher. If the horse is drawn too high the animal cannot swallow with ease or even with safety.

The person giving the drench should stand on some object in order to reach the horse's mouth on a level, or a little above it. The bottle is then to be introduced at the side of the mouth in front of the molar teeth, in an upper direction. This will cause the horse to open his mouth, then the base of the bottle is elevated, and about four ounces of the liquid allowed to escape on the tongue as far back as possible, care being taken not to get the neck of the bottle between the back teeth. The bottle is to be immediately removed, and if the horse does not swallow, this can be encouraged by rubbing the neck of the bottle against the roof of the mouth, occasionally removing it. As soon as it is swallowed repeat the operation until he has taken all the drench. If coughing occurs, or if, by any mishap, the bottle should be crushed in the mouth, lower the head immediately.

In drenching, swallowing may be hastened by pouring into the nose of the horse, while the head is high, a few teaspoonfuls of clear water, but drenches must never be given through the nose. Large quantities by pouring into the nose are liable to strangle the animal; if the medicine is irritating, it sets up an inflammation of the nose, fauces, windpipe, and sometimes the lungs.

Medicated vapors are to be inhaled by placing a bucket containing hot water to which carbolic acid or any other coal-tar product has been added. The horse's nose is to be inserted into the top of the bag, and he thus inhales the medicated steam. Care must be taken not to have it hot enough to scald the animal. The vapor from scalding bran or hay is often thus exhaled to favor discharges in sore throat or "distemper."

By the Rectum: Medicines may be given by the rectum when they cannot be given by the mouth or when they cannot be retained in the stomach; when we want a local action on the last gut; when it is desired to destroy the small worms infesting the large bowels or to stimulate the peristaltic motion of the intestine and cause evacuation. Medicines are, in such case, given in the form of liquid injections. Foods may also be given this way.

Enemas: When given for absorption they should be small in quantity, neutral or slightly acid in reaction, and of a temperature of from 90° to a 100° F. These, like feeds given by the rectum, should be introduced only after the last bowel has been emptied by

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the hand or by copious injections of tepid water. Enemas, or clysters, if to aid the action of physics, should be in quantities sufficient to distend the bowel and cause the animal to eject them. Simple water, salt and water, or soap and water, in quantities of a gallon or more may be given every half hour. It is best that the horse retain them for some little time, as a liquid serves to moisten the dung and favor a passage. Stimulating enemas, as glycerine, should be administered after those already mentioned have already emptied the last bowel, with the purpose of still further increasing the motion of the intestines and aiding the purging medicine.

Ordinary cold water or even ice-cold water is highly recommended by many as a rectal injection for horses overcome by the excessive heat of summer.

Shoeing

The officer of the battery who is responsible for the care of the horses must have an intimate knowledge of the principles of horseshoeing in order to properly carry on his duties. The horses' feet need constant attention in order to keep them fit for work. With cleanliness and dryness in the stable and on the picket line the horses' feet will be healthy and this with proper shoeing will go far toward eliminating the sick list. The officer must know what proper shoeing is and be able to direct the work of the horseshoers of his organization. The shoeing book is kept in the battery to show when each horse was shod. A horse should be shod at least once a month or have his feet trimmed and his shoes reset if they are serviceable.

In removing the shoe the clinches are first lifted with the clinch cutter. With the pincers one branch of the shoe is grasped and slowly lifted from the hoof by carrying the handles of the pincers in the direction of the toe. The other branch is loosened in like manner. The toe is then seized and by carrying the handle of the pincers toward the heel the shoe is lifted from the foot. By carrying the handle of the pincers always in the direction of the center of the hoof the danger of breaking off pieces of the wall is avoided. Be sure that all nails are removed from the foot with the shoe for a nail left in the hoof will cause trouble later on.

The most important part of shoeing is the preparation of the foot for the shoe. With the hoof knife all fragments of horn are removed and the hoof cleaned off. The wall of the hoof is then cut down with the cutting nippers to its union with the sole, so that at least one eighth of an inch of sole is in the same level as the bearing sur-

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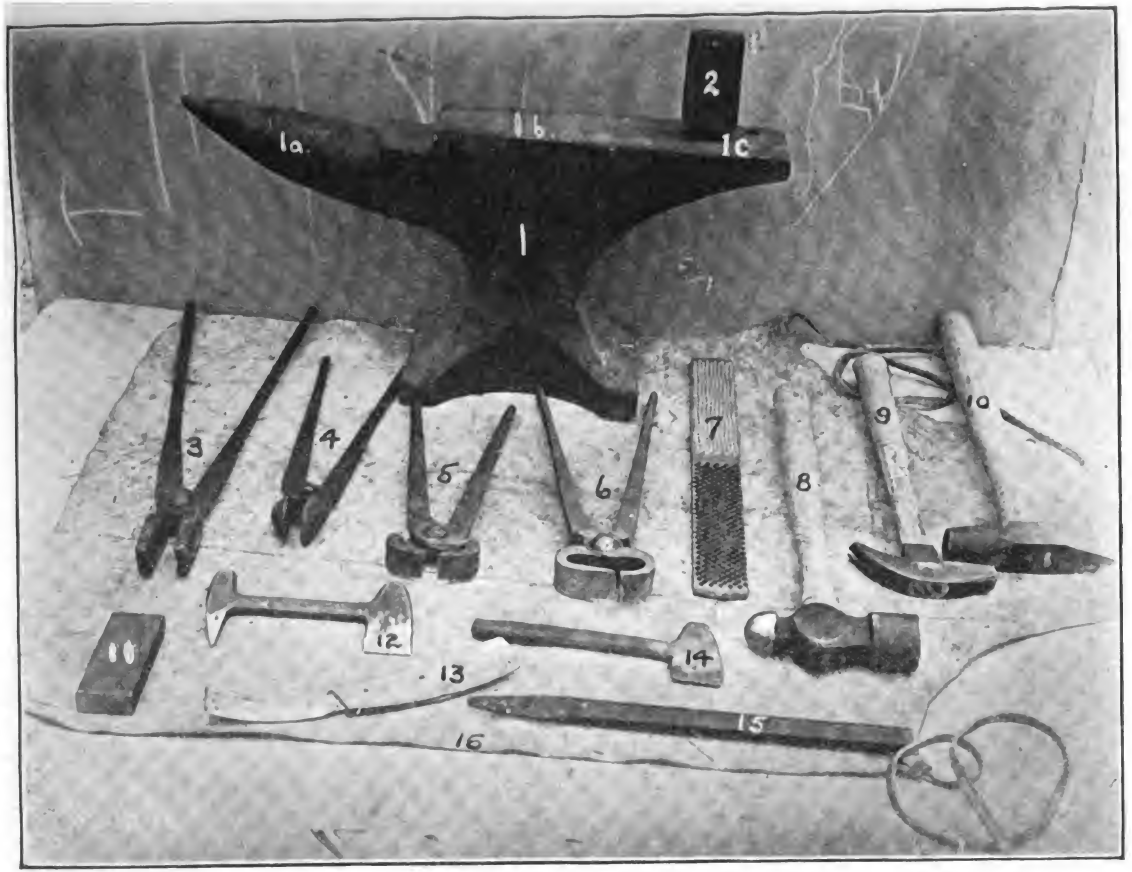

HORSESHOEING TOOLS

1 Anvil.
1a Horn.
1b Face.
1c Heel.
2 Hardie.
3, 4 } Shoeing Tongs.
5 Pinchers.
6 Cutting Nippers.
7 Horsehoer's Rasp.
8 Ball-peen Hammer.
9 Driving Hammer.
10 Chisel for Hot Iron.
11 Clinching Iron.
12 Clinch Cutter.
13 Shoeing Knife.
14 Creaser.
15 Pritchel.
16 Apron.

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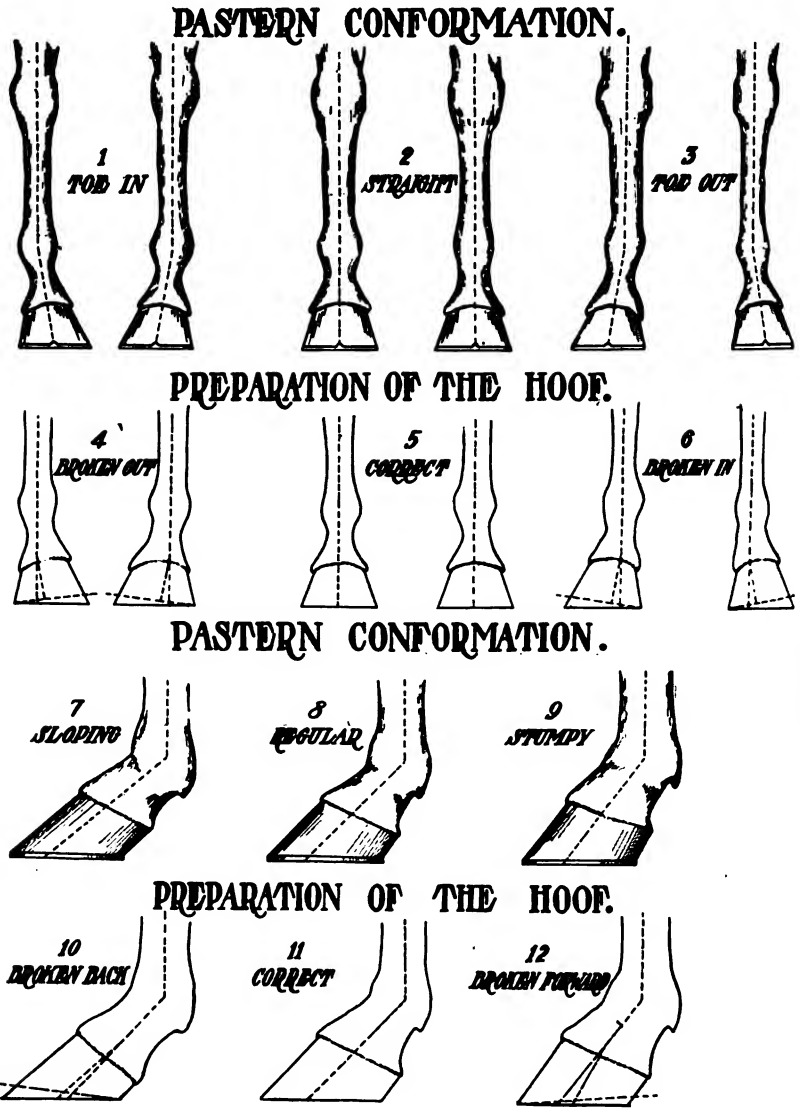
face of the wall. With the rasp smooth the bearing surface until it is perfectly horizontal. The frog should never be cut except that



dead pieces may be removed with the cutting nippers. When cutting the wall a good rule to follow is to start at the quarter and increase the depth of cut toward the toe.

The foot should be so trimmed that the frog has contact with

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the ground. The bars should not be cut unless they are too long. The outer surface of the wall should never be rasped for by breaking the surface the natural moisture escapes and the wall becomes dry and brittle.

When observed from the side the axis of the foot should be so inclined that the wall at the toe and the long pastern will have the same slant. The hoof has been properly prepared when the horse in motion places the foot flat upon the ground and does not put one side of the shoe down first. The two front hoofs and the two hind hoofs when the legs are in the same position should be of equal size and in proper relation to the size and weight of the body.

The lightest shoe that will give the service required is the proper shoe to put on. The shoe should be made to fit the foot instead of rasping the foot to the shoe. The nails should be driven in along the white line between the wall and the sole. They should pierce the outer surface of the wall one inch from the bottom. A clinch is sufficiently long when it equals the width of the nail at that point. The clinch must be inspected to see that no sharp edges are left to injure the horse. The shoe should have the form of the foot to the last nail hole on each side and then spread slightly to allow for expansion of the heel when the horse's weight comes upon it. The wall of the hoof only should rest on the shoe and for that reason the hoof-surface of the shoe is concaved to avoid pressure on the sole. Never permit the seat for the shoe to be burned in the hoof with a red-hot shoe.

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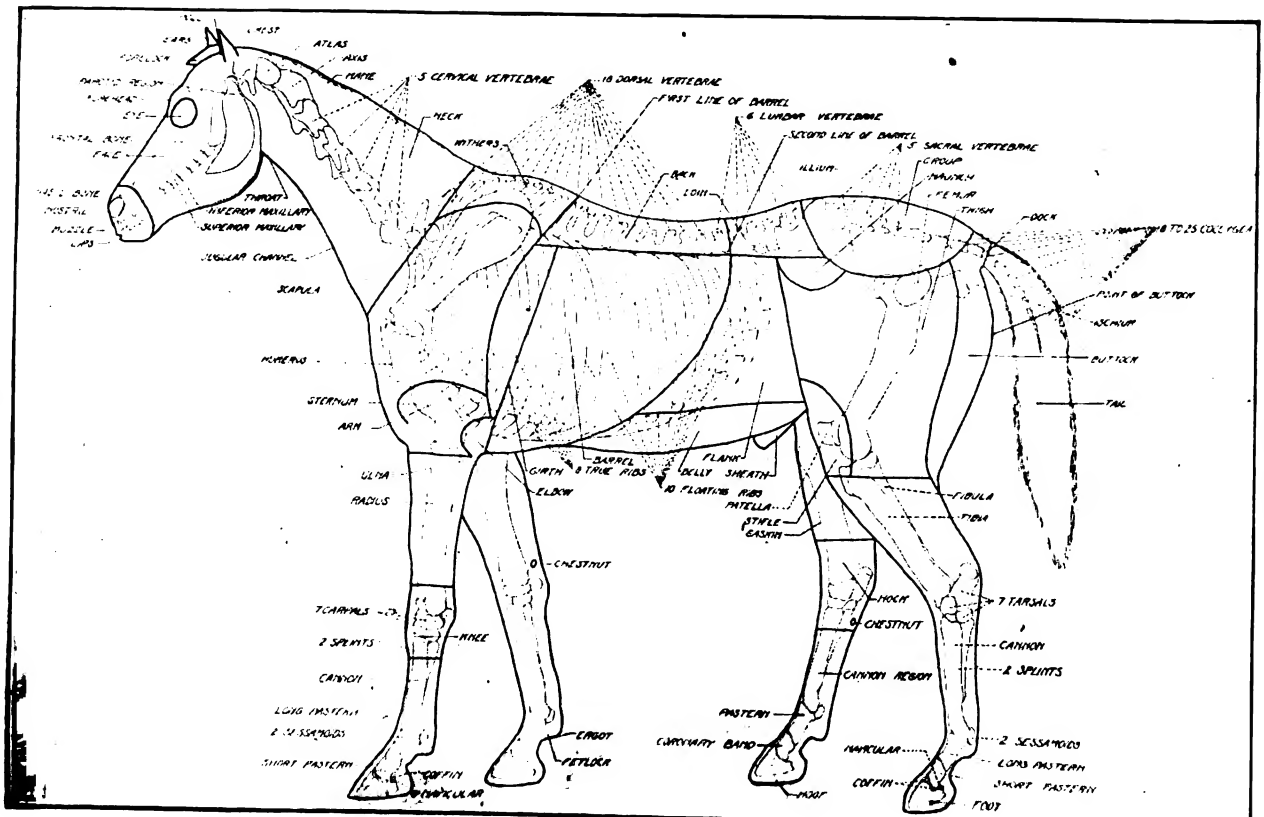

EXTERNAL REGIONS AND SKELETON OF THE HORSE

Heavy black outlines denote areas of the points of the horse. Dotted lines refer to the nomenclature of the skeleton; plain lines to the nomenclature of the points.

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CHAPTER XII

RIDING AND DRIVING

Riding

A WESTERNER once said his work called for only two gaits in a horse, the walk and the run. The demands of the Service require an intermediate speed; this is given by the trot. The Army horse has three gaits, the walk, the trot, and the gallop; and the regulation speed of these is four miles, eight miles, and twelve miles per hour respectively. By a variation any speed up to sixteen miles an hour can be obtained. The slow walk, slow trot, and slow gallop give a rate slightly slower than regulation, while by walking out, trotting out, and the extended gallop, the faster rate can be obtained. Experience has proven that the horse can maintain the regulation rate longer and with less waste of energy than he can the others, and that his endurance and useful work are greater. For all maneuver work the regulation rates are prescribed.

The army rider must have control of his horse at all gaits. This control can only be obtained through practical training by the development of a good seat. The beginner must learn to sit on the horse by a combination of balance and muscular grip. When he has confidence in his ability to stay on the horse, instruction in the aids commences. The rider conveys his wishes to the horse mainly through the medium of his hands, legs, and weight,—commonly known as the aids.

The rider should sit down in the lowest part of the saddle and maintain his seat by the leg grip and the balance of his body.

Before any instruction in the seat is given the beginner should be taught how to stop the horse. To be on a horse and feel powerless to stop him does more to destroy confidence than any other one thing.

There is a certain relation between the center of gravity and the gait at which the horse moves. By leaning backward on the horse, the combined center of gravity is moved backward. In addition,

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if the position of the horse's head is moved there is a further change in the center of gravity. Therefore when the beginner wishes to stop the horse he should pull with the reins and lean back slightly, then give with the reins and recover the erect position; continuing to pull and give until the horse responds. The running horse often seizes the bit in his teeth and a hard steady pull has no effect on him; but if he is given the reins, his head and neck go forward, and his balance is disturbed to such an extent that it requires an immediate adjustment of gait. By alternating pull and give, and thus working on the balance, the hardest mouthed horse can be controlled. Once the rider realizes that he can stop the horse at will, he gains in confidence and is ready to take up the aids and develop a good seat.

A good seat in the saddle has been described in many different ways, but the underlying principles do not change. The rider should sit well down in the lowest part of the saddle, and let his legs hang naturally. A common fault is to have the legs too far to the front and the weight on the cantle of the saddle. This produces sores on the horse's back where the bars of the saddle press unevenly. By constant riding the muscles of the thighs gradually shape themselves to the horse, and the rider works down into the proper part of the saddle. From knee to knee there should be close firm contact with the horse, and at the same time there should be light contact with the calves of the legs.

At no time should the rider have a tense unyielding grip, for then the horse loses sensitiveness to the varying degrees of pressure needed in the proper application of the aids. The lower legs should hang just slightly behind the vertical, where they are ready for use on the horse's sides behind the cinch. The heel should be slightly lower than the toe, while the ball of the foot rests in the stirrup. There should be no stiffness in the foot or leg for the knee and ankle act as shock absorbers when flexible.

So much for the part of the body around the horse. The body above the horse should be supple and never stiff. The back from the belt down should bend outward and down into the saddle, while the upper part should be erect. The body from the waist up should be loose and flexible. The shoulders and arms should take the motion of the upper body and should never flop in an exaggerated fashion. The head is carried erect and the shoulders squared. The upper arm falls naturally at the side and the forearm is nearly horizontal.

The wrist and hand require the most attention. When the horse takes a step, the rider is given an up and down motion, while the horse's head moves backward and forward. The wrist, hand, and

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fingers must coördinate these two motions so that there is a light feel of the mouth at all times. The reins must never flap nor must there be a jerk on the horse's mouth at every step. A constant effort should be made to develop a hand which shall be light and at the same time firm, a touch which keeps the rider in constant communication with the horse through the reins.

A poor hand invariably irritates the horse and excites him; with the beginner, this results in loss of control of the horse.

Common faults are: Sitting with the weight of the body resting on the cantle of the saddle.

Leg rigid and the weight supported on the stirrup.

Lower leg pushed to the front and out of contact with the horse.

Upper body inclined forward.

Reins flapping or jerking the horse's mouth.

Keeping the body in place by means of a steady pull on the reins.

To Mount without Saddle

Being at stand to horse, at the command **"Mount,"** face to the right, drop the right rein, grasp the left rein in the right hand, take two steps to the right, sliding the hand along the left rein. Make a half face to left when opposite girth, and with the aid of the left hand take both reins in the right hand, forefingers between the reins; right hand well back on the withers, the reins coming into hand on the side of the forefinger, held so as to feel lightly the horse's mouth, the bight falling on the off side. Grasp a lock of mane with the left hand, springing up to the position of "Leaning Rest," arms extended, body inclined slightly forward, resting weight on right hand, pass right leg, knee bent, over horse's croup. Sit down lightly on horse's back.

To Dismount without the Saddle

Grasp the reins with the right hand in front of and near the left hand, forefinger between the reins, the reins entering the hand from the side of forefinger. Drop the rein with the left hand. Place the right hand well back on withers. Grasp lock of the mane with left hand, raise the right leg, knee bent, over the croup. Take the position of Leaning Rest, arms extended, body bent slightly forward, legs and body on near side of horse. Lower body lightly to ground. Stand to horse.

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To Mount with Saddle

Being at stand to horse, at the command "**Mount,**" face to the right, drop the right rein, grasp the left rein in the right hand, take two steps to the right, sliding the hand along the left rein, make a half face to the left when opposite the girth; with the aid of the left hand take both reins in the right, forefinger between the reins, the right hand on the pommel, the reins coming into the hand on the side of the forefinger, and held so as to feel lightly the horse's mouth, the bight falling on the off side. Place the left foot in the stirrup, assisted by the left hand if necessary, and bring the left knee against the saddle; grasp a lock of the mane with the left hand, lock coming out between the thumb and forefinger.

Spring from the right foot, keeping the hands firmly in place, the left knee bent and pressed against the saddle, bring the right foot by the side of the left, **body inclined slightly forward, pass the right leg,** knee bent, over the croup without touching it, sit down lightly in the saddle; let go of the mane; insert the right foot in the stirrup, assisted by the right hand if necessary.

The rider should be careful to avoid touching the horse with the left toe in mounting: this fault causes nearly all resistance of horses to standing quietly while being mounted.

The rider in adjusting the reins provokes no movement and deranges in no manner the position of the horse's head.

To Dismount with Saddle

Grasp the reins with the right hand in front of and near the left hand, forefinger between the reins, the reins entering the hand from the side of the forefinger; drop the reins with the left hand; place the right hand on the pommel; grasp a lock of the mane with the left hand, the lock coming out between the thumb and forefinger; take the right foot out of the stirrup.

Rise upon the left stirrup, pass the right leg, knee bent, over the croup without touching the horse, and bring the right foot by the side of the left, the left knee against the saddle, the upper part of the body inclined slightly forward; descend lightly to the ground and take the position of stand to horse.

The most essential aids are the reins and legs.

The legs serve to urge the horse forward and to bring his hind quarters up under him or move them laterally. The legs act by the pressure of the calves. It is essential to have from the horse perfect obedience to the action of the legs. He should respond to equal pressure by both legs by engaging his hind quarters and moving

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forward; to predominant pressure of one leg by moving his haunches in the direction away from that leg. The action of the leg should cease as soon as obedience is obtained.

The reins serve to prepare the horse to move, to check him, increase his gait, or change his direction. The reins are held in the hand so that they enter under the little finger and pass over the forefinger. The thumb presses them lightly upon the second joint of the forefinger. By closing and relaxing the fingers and flexing the wrist, arm, and shoulder, the rider, while maintaining contact and keeping the reins taut, can follow the movements of the horse's head without interfering with these movements. The hand is then said to be passive and it should be kept so as long as the rider does not desire to change direction or gait.

In gathering the horse or increasing or decreasing the gait the rider should close his fingers on the reins without raising or lowering them and the action should be from front to rear. This action should not be continuous. The fingers should be alternately contracted and relaxed, the hands remaining low and preserving contact between the actions. This is known as the effect of the direct rein.

In changing direction the hand acts in two ways. When the hand is carried away from the horse's neck the rein is said to be opened. As the open rein has a tendency to draw the horse's head to that side and lead him in that direction it is also called a leading rein. When the rein is carried slightly upward and against the horse's neck it bears against the neck and turns him in that direction. This gives it the name of bearing rein. Both open and bearing reins should act without increase of tension from front to rear and intermittently like the direct rein. The hand should always be kept low.

Before the horse is required to execute any movement he should be given a preparatory signal. Whatever the movement, the signal is always the same. This signal serves to attract his attention and prepare him for the movement; it is called gathering the horse.

Having a light pressure of the bit on the horse's mouth and a light feel of the lower leg against the horse's sides, in order to gather him increase the pressure of the lower leg against the side and slightly increase the pressure of the bit against the bars of the mouth by squeezing the fingers on the reins. Increase these two pressures until the elastic movement of the horse under the rider indicates that he has observed the signal. If, when at a halt, the horse moves forward, or when moving he increases his gait, the impulse given by the legs has not been met by the fingers. If when at a halt the horse backs, or when marching decreases his gait, the fingers have

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been contracted too much. Each force should exactly balance the other, and the horse, held between the two, should seemingly grow into an elastic body under the rider.

The action of the reins and legs and weight, as aids, should not be continuous: the rider alternately closes and relaxes the fingers, the hands preserving contact in the intervals between the actions; in the same manner he uses the legs, neither gripping nor releasing altogether, but preserving light contact in the intervals between the blows with the calves; and the weight, likewise, thrown quickly to the front, to the rear, or sidewise, and alternately returning to the normal position.

All action of the aids should diminish in intensity when obedience begins, and cease entirely as soon as the desired result is secured.

The hands must be kept still; that is, free from bobbing up and down, pulling, and from giving and taking when there is no reason therefor.

Likewise the legs should remain in light contact with the horse's sides, and not continuously be used by kicking the horse in a nervous manner.

The effects of the aids must be perfectly clear and there should be no contradiction between them. This condition is essential for preserving the composure indispensable to the horse.

To move forward the horse is first gathered. The lower legs are then carried backward in rear of the cinch, and with a forward motion squeezed into the horse's sides. After the squeeze has been started the pressure on the reins is decreased and the horse should move forward. In other words the inward and forward motion of the legs gives the horse an impulse to move forward, which impulse is held in check until the opposition of the bit is removed. In starting a horse, if he does not respond to the first squeeze, tap him gently with the calves, increasing the pressure until he obeys the signal to move forward. If this fails to rouse him, use the heels or spurs, gently at first and gradually increasing in severity until he responds. The spurs should never be used until the use of the calf fails to get the horse's attention.

To increase the gait, repeat the aids used to move the horse from the halt to the walk.

To decrease the gait, sit well down in the saddle, increase the pressure of the legs, carry the weight back by curving the back outward and pull in slightly on the reins. As soon as the horse slackens the gait ever so little let up on the reins slightly and decrease the pressure of the legs a bit. Alternate the pull and give of the reins and the squeeze and relax of the legs until the horse has completed

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the movement desired. The increased pressure of the legs causes the horse to bring his hind feet up under him to act as brakes in stopping himself. The weight of the rider's body moved backward helps hold these brakes in place by carrying the center of gravity back over the hind legs.

Normally all the tension necessary on the reins in decreasing the gait is obtained by contracting the fingers on the reins as the body moves to the rear and the hands maintain their relative position to it. If this is not sufficient bending the wrists will give additional pressure. A steady pull should never be used.

To change direction carry back slightly the leg on the side toward the new direction and increase the pressure of both legs. The rein on the side toward the new direction should be opened while the other rein becomes the bearing rein. That is, in the turn to the right, carry back the right leg, open the right rein, bear against the neck with the left rein, and regulate the pressure of each leg so that the horse's body follows the curve of the turn and his front and hind feet pass over the same ground. If his haunches go outside the curve, the pressure of the left leg should be increased. When the rider carries the reins in one hand, it is only possible to use the bearing rein.

To increase or decrease the speed of the gait, the rider employs the means prescribed for passing from the halt to the walk, or from the walk to the halt, to the extent necessary to obtain the desired result.

The horse, in extending the walk, increases the amplitude of the movement of the head and neck as he increases the cadence of his step.

The rider aids these movements by yielding the hand and giving the horse greater freedom of movement. He maintains contact with the bit so that he can exercise a gradual restraining influence with the direct reins when he feels the horse is about to spring into the trot.

To decrease the pace at a walk the rider makes use of the same aids as in coming to the halt. The step is shortened and the cadence decreased.

To increase or decrease the pace at the trot the same means are used. The exercises in increasing and decreasing the pace afford excellent practice for the rider in the use of the aids and good training for the horse in obeying them; but the rider out of ranks should use only the regulation gaits.

The gallop is the most rapid of the gaits. It must not be used unnecessarily over long distances, particularly on hard roads. How-

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ever, when the rapidity of the regulation trot is not sufficient, the rider out of ranks should take the gallop in preference to increasing the speed of the trot.

The varieties of the gallop are:

The maneuvering gallop, which is at the rate of 12 miles per hour, or 352 yards per minute.

The extended gallop, which is at the rate of 16 miles per hour, or 469 yards per minute.

The school gallop, which is at the rate of about 8 miles per hour.

The horse is said to gallop with the right lead when the right fore is planted in front of the left fore and the right hind in front of the left hind.

When the feet are planted in the inverse order the horse is said to gallop with the left lead.

The gallop is marked by three beats and a period of suspension.

If the horse is galloping with the right lead, the first beat is marked by the left hind foot, the second by the nearly simultaneous placing of the right hind and the left fore feet, and the third by the placing of the right fore foot.

In galloping with the left lead, the beats are: right hind, left hind, and right fore, left fore.

A horse gallops true when he gallops with the right lead in turning to the right and with the left lead in turning to the left.

He gallops false when he gallops with the left lead in turning to the right, or conversely.

A horse is disunited when he gallops with the right lead with his fore feet and with the left lead with his hind feet, or conversly.

The gallop should be begun on the circle because the horse thus starts off more calmly and the rider is enabled to regulate the pace by describing a circle of greater or less radius.

As soon as the horse breaks into the gallop the rider moves in cadence with his horse. The back and legs unite in the rhythm of the gait, the hands accompany gently and without exaggeration the movements of the head and neck.

The aids used to obtain the gallop with the right lead, for example, are: left direct rein, to restrain the left shoulder; left leg a little in rear of the girth, to push the haunches a little to the right; weight slightly on the left buttock; right leg on the girth; right rein taut to prevent bending the neck too much to the left; both legs, thus placed, used vigorously to push the horse into the gallop.

To move backward, gather the horse and then pull back gently on the reins, at the same time carrying the weight backward. As soon as the horse shows the slightest response, relax the fingers and

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continue alternating pull and relax until he has made the required movement. To keep the horse moving straight back the pressure of the legs can be regulated to oppose any lateral movement of the haunches, or by the use of the open and bearing rein the horse's shoulders can be placed so as to counteract the movement of the shoulders. The horse should never be backed far and after backing should be moved forward a few steps.

Posting is habitually employed when the riders have stirrups and understand their use.

It is executed as follows: The horse moving at a trot, the rider inclines the upper part of his body forward, then, supporting himself on the stirrups while maintaining the clinging of his knees, he rises under the impulsion of the horse, maintains his position detached from the saddle while the succeeding impulse is produced, again sits down in the saddle, and continues in this way always avoiding every other impulse.

At the beginning the mechanism of posting is made easier to the rider by causing him to stroke the horse's neck or to grasp a lock of the mane with either hand, thus determining the forward inclination of the body.

Its proper execution requires that the seat be raised moderately, that contact with the saddle shall be resumed gently and without shock, that the full support of the stirrup is obtained, while keeping the lower leg steady, that the ankle joint shall be supple, and that the heel shall be kept lower than the toe.

Changing the Diagonal in Posting

The right fore and left hind feet constitute the right diagonal; the left fore and the right hind feet, the left diagonal.

In posting, the rider is said to post on the right diagonal when, after rising, he sits down in the saddle at the instant the right fore foot comes to the ground.

It is important that the rider post for a time on one diagonal and then change to the other, so that the diagonal pairs will each perform the same amount of work and the chance of injury will be reduced.

To automatically insure that the posting is done as much on one diagonal as on the other the riders are required to post on the right diagonal when riding to the left hand on the track, and on the left diagonal when to the right hand.

The instructor occasionally requires each rider to inform him on which diagonal he is posting.

To change the diagonal, the rider diminishes the weight borne on

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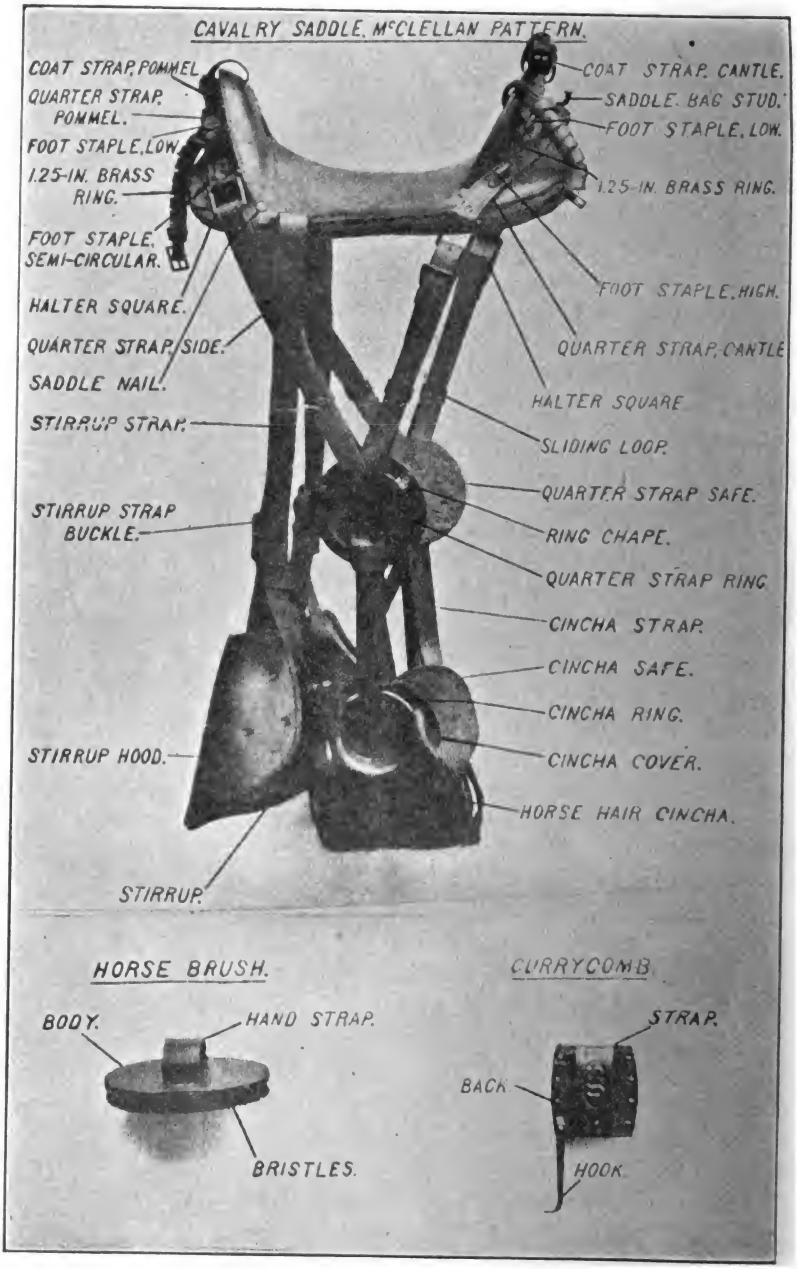

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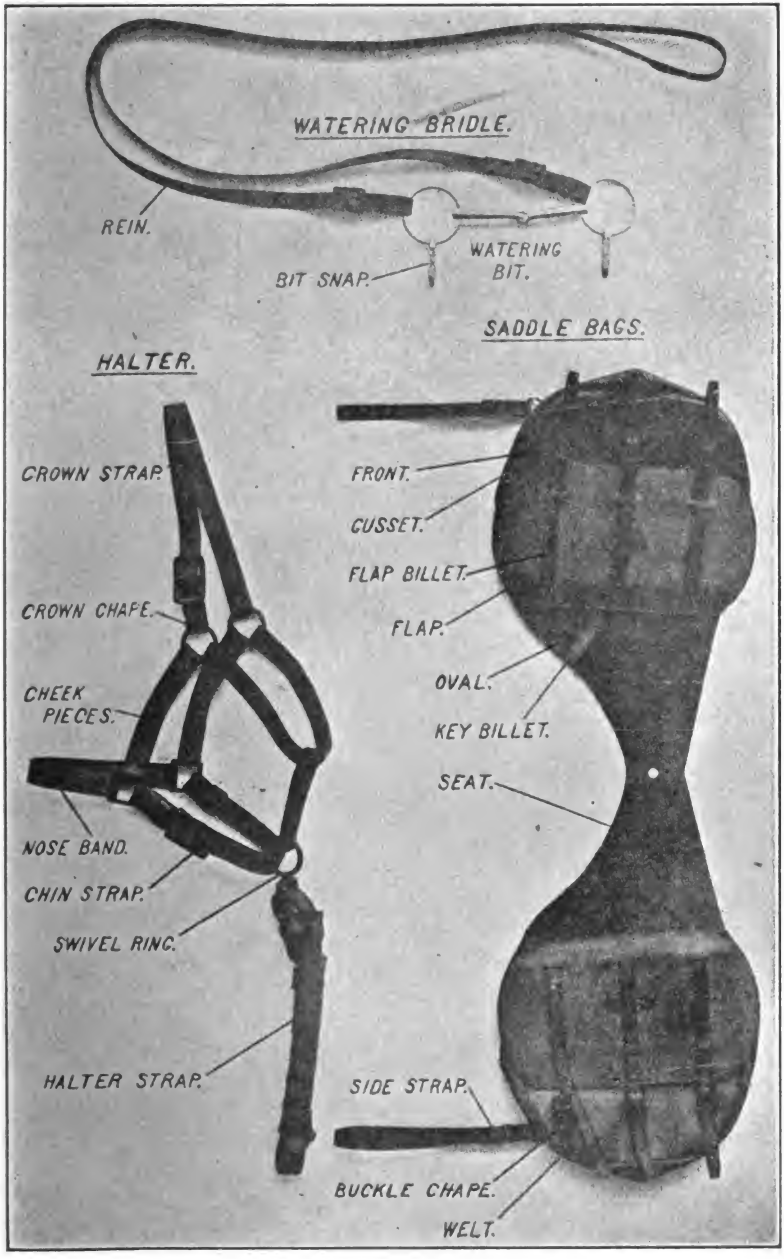

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the stirrups and retains his seat in the saddle for two successive beats of the horse's feet instead of one; he then rises as before. The rider will then find himself posting on the diagonal opposite to the one on which he was posting before.

PRINCIPLES OF DRAFT AND DRIVING THE ARTILLERY HORSE

(Greater Part from Lecture by General W. P. Ennis.)

In the discussion of the principles of draft as applied to the artillery team, it is necessary to consider: (first) the construction of the artillery carriage; (second) the physical conformation of the horse as a mechanical device.

The Construction of the Artillery Carriage

In the construction of field-gun carriages it is considered that seven hundred pounds dead weight is the maximum load each horse can pull under severe conditions, that two hundred and fifty pounds horizontal pull is the greatest average that can be obtained from each horse in a six-horse team.

Within limits, the higher the wheel the easier the draft. The width of the tire also has an appreciable effect in the resistance offered to different kinds of road-bed.

The length of recoil of the gun and the stability of the carriage during firing are also very important considerations.

After a series of experiments covering all these subjects the Ordnance Department has decided on a 56-inch wheel with a 3-inch tire as the most advantageous for the 3-inch field carriage.

In rolling friction the force applied should be parallel to the direction of motion. With the 56-inch wheel, the wheel trace by itself makes an angle of about 8° with the horizontal but the pull of the lead horses ahead decreases this angle to about 6°.

The Physical Conformation of the Horse, as a Mechanical Device

The power of the horse to move loads is accomplished by the animal pushing against the collar which is connected to the carriage by the traces. The greater part of the force of propulsion comes from the hind legs, through the back to the shoulders, and a smaller amount from the front legs to the shoulders.

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A certain amount of push, depending upon the weight of the animal, acts through the center of gravity by the horse's leaning forward against the collar. This last force is that due to the animal's weight and is not muscular force. We thus have three forces acting: the hind legs, the forelegs, and a component of the animal's weight acting through the center of gravity. The center of gravity of the horse is approximately at the intersection of the vertical line passing through the eighth dorsal vertebra and a horizontal plane passing through the points of the shoulders.

From this we can see that when the horse leans forward in draft the center of gravity is in front of the mean position of contact of the feet with the ground.

A line from the mean position of the hind legs with the ground to the center of the shoulder blade will represent the direction of the resultant force exerted by the hind legs; and a line from the mean position of the forelegs to the center of the horse's shoulder blade, the resultant force exerted by the forelegs. From an inspection of the skeleton of the horse, it will be seen that the resultant direction of these three forces is approximately perpendicular to the line of the shoulder blade.

Considering the horse alone, the line of draft should then be perpendicular to the line of the shoulder at its middle point. The shoulder blade rocks back and forth as the horse moves his forelegs. The center of motion of the shoulder blade is about at its center. If the trace is attached above or below this point, whenever that half moves forward there is a heavy pull trying to limit its motion. It is the same principle as if you tried to pull some object with the strap around both knees. When fastened to the center of the shoulder, however, the pressure is still there, but there is nothing tending to limit the forward movement of the lower part of the shoulder.

While we see that the construction of the carriage compels almost horizontal draft, the conformation of the horse and the necessity of protecting the shoulders from injury must control the direction of pull from the shoulder. This is accomplished by the "holding-down strap" used on swing and lead teams and by the "holding-up strap" on the wheel horse. This applies to the steel collar. The breast collar is so constructed that the line of pull must be horizontal to prevent interference with the movement of the shoulders and to eliminate the downward pull which causes sore necks and shoulders. The lead and swing pairs are usually about the same size, making the pull on these two pairs practically horizontal, and so no holding-down straps are required. The holding-up strap is necessary to make pull horizontal on the wheel pair.

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It is necessary to bear in mind that the horse has but one idea at a time. This fact is of great assistance in making horses do things that they believe they cannot do or do not want to do.

It is also necessary to realize that the horse is not naturally obstinate and that 90% of them are willing to do whatever is asked as soon as they understand what is wanted. The so-called obstinate or balking animals have been made so by bad treatment or improper training. The horse is one of the easiest of animals to train.

It cannot be too strongly emphasized that kindness and patience will accomplish the object desired in much shorter time and with infinitely better results than roughness and brutality.

The Driver

The driver takes the position of the soldier mounted. There is a tendency when driving a pair to put more weight in one stirrup than in the other, especially when pulling up the off horse. This pulls the saddle out of place and if continued will cause saddle sores. Wheel drivers, to protect their inside foot and ankle from the thrash of the pole, ride with one foot resting on it. This also pulls the saddle out of place and should not be permitted.

Management of Pair

The driver is responsible for the proper handling of his pair. The near or saddle horse is controlled by the reins, spurs, and legs of the driver, the off horse by the reins, whip, and voice. The near horse is made to move to left or right by the neck rein, not direct rein. The off horse will follow near horse. With properly trained horses the whip and spur are not necessary. With inexperienced men, it is best to forbid their use entirely. The driver should never try to guide the off horse by the use of one of the off reins. The off reins should be so adjusted that the off horse's head is straight to the front, that the two parts of the off rein are of equal length; this adjustment should never be varied.

The gait, at which you are drilling or marching, governs to a large extent the handling of the pair. The driver must be alert at all times, ready at any moment to change the gait of the pair.

He must constantly keep his eyes on the pair and column ahead and regulate his gait accordingly.

It is most important that the leading driver of the guiding team keep a uniform gait. The driver, at all times, except when in hard draft, or when on road marches at a walk, should have a slight feel

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of the mouths of his horses. When in hard draft where the footing is good the horses should be allowed to take their heads (give them a loose rein), as a horse cannot pull properly unless he puts his nose well to the front. If necessary, drop the reins entirely.

When at a walk on road marches the horse should be allowed a loose rein in order to rest him. The exception to this rule is when in a hard pull on slippery ground the horse needs slight support from the reins.

The driver should never keep a constant pull on the reins, for by so doing, he stops the circulation in the bars of the mouth and

the bars then become insensitive to pressure. If necessary to keep a horse back, do it by a give and take on the reins.

The off horse, as a rule, should be handled by the reins held in the right hand, the near horse by the reins held in the left hand. The lash of off rein may be held in left hand.

The drivers should watch the amount of work their animals are doing and require them to do only their just share. By watching the traces ahead of him, the driver can tell whether the pair ahead is pulling. By watching the tug on the collar of his off horse he can tell whether that animal is doing his part. With a little experience a driver can tell from the movement of his saddle horse how much he is pulling. It requires constant supervision and instruction on the part of the officers and noncommissioned officers to teach drivers to drive properly. If left alone one driver will make his near horse do all the work while another does the opposite. If one pair is pulling more than its share, it should be held back until the tightening of the traces ahead shows that the pair in front is doing its share.

The whip and spur should be used with great caution and never violently, the whip by a wrist motion only and on the off side of the off horse and in rear of the blanket. The less the whip and spur are

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used by the majority of the drivers of field artillery, the better pulling the battery will do. Never allow the whip to be used on any horse of a stalled team as it will make the team much more liable to quit on the next pull. Never use whip, hand, or foot on the near side of the off horse. Any such treatment will cause the off horse to pull away from near horse. The best position for draft is with both horses of a pair working close together. The voice is decidedly the best aid for the off horse. Teach the horse to move when spoken to. If the whip is used, use the voice at the same time, so that horse will always associate the two.

In driving down all steep slopes—take the slope at right angles, otherwise there is danger of overturning the carriages. In negotiating a ditch, all drivers hold back until the wheel horses are in the bottom of the ditch, then lead and swing move out at an increased gait to get out of the wheeler's way and to get into the collar in time to help on the pull up the other side.

The wheel driver is responsible for the movement and guidance of his carriage, for, except in hard pulls, he can always increase the gait of his pair and slack the traces ahead to obtain control of his carriage. In a hard pull the wheel pair is not capable of doing this and here the lead driver should be held responsible for the guidance of the carriage.

To Start the Team

Traces at all times should be stretched when the team is halted. To move forward the pairs should be gathered by their drivers. The near horse is gathered by the reins and legs of the driver, the off horse by the reins and voice. At the command "March" all pairs should move out together. If, for any reason a team has been stalled the horses may become more or less excited and will not make a fair effort to pull; they can generally be persuaded to pull again by the following method: Back all the horses up until they are as close together as possible, then move the lead team out quietly and at the same time pass them to the right. Have the swing driver watch the lead traces and as soon as they start to tighten he should move his pair forward, going over the same ground that the lead pair passed over. The wheel driver watches the traces of the swing pair and moves out when they tighten. As soon as all traces tighten the horses must be required to give their maximum effort by use of the aids and voice. In some cases due to conditions preventing movement to the right, the lead pair may be moved to the left, and accomplish the same purpose.

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The above method will work for tne following reasons: The lead pair has taken six or eight steps forward before any pressure comes on their shoulders, the swing pair three or four, and the wheel pair sees the other horses going to the front. This conveys to the horse the idea that everything is all right and he is willing to try again. The pole, being turned to the right, gives considerable leverage on the hind wheels, the horses in passing to the right come into the collar more gradually. The reason for going to the right is that

it is very much easier to control the off horse and keep him in the collar than it would be in moving to the left. It is impossible to control the off horse in draft unless he is working close to the near horse. If there is any chance that the team cannot pull out immediately, use the cannoneers on the wheels to assist the horses.

In stopping carriages or decreasing their gait the lead and swing drivers must remember that the wheel pair have the carriage to stop and for that reason need a longer distance to the front to change the gait than the lead and swing pairs do. Never allow sudden changes of gait where it is possible to avoid them. The gait in a hard pull should be slow, from one to one and a half miles per hour. Do not allow plunging or rushing any grade. In halting or decreasing gait of a carriage, the wheel driver should slow up before the other drivers so as to tighten traces.

Turns in Draft

In all turns in draft each horse of the team should be doing his share of the work. Each pair of the team should turn on the same ground. This means that the team is convexed outward during the turn and that each inner horse of a pair is ahead of the outer horse. The traces in all but sharp turns should be taut.

Each driver has to keep his pair outward on the turn and especially the wheel driver. In order to keep the pole outward the driver

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must make his inner horse do most of the work for the wheel pair during the turn, as it is comparatively easy to pull the pole around but very hard to push it over. In making sharp turns to the right where it is necessary to keep the teams bowed outward, it is often necessary to use the coupling rein of the off horse in order to lead the off horse forward and to the left. The off horse, when very far behind, may also be led forward by the coupling rein, but as soon as he is up in place the coupling rein should be dropped and the reins taken. These are the only two instances in which the coupling rein should be used.

Following teams must make the turn on the same ground as the team ahead. This means that the lead driver goes outside the track of the carriage ahead as the rear wheels of this carriage turn on an arc of much smaller radius than the team. This also means that the inner horse of each pair moves on an arc about one yard outside of the track of the outside rear wheel of the carriage ahead.

In making sharp turns where there is little room and the pull is severe the pairs will be unable to move on the same ground and the turn must be made as follows: The lead driver moves straight to the front until the wheel driver arrives at the place to turn. The lead driver then turns in the proper direction at an increased gait in order to keep the traces taut, the swing driver follows the lead driver and must keep his traces in draft. The necessity for the increased gait of the lead horses in making the turn is that the lead animals turn on an arc of greater radius than the wheel horses and therefore must cover greater distances than the wheel horses and in the same interval of time. This applies to sharp right angled turns where it is necessary to go through a very narrow place.

Emphasize in sharp and difficult turns on level ground that the wheel driver controls the carriage and that the lead and swing give him slack traces, but keep moving to get out of the wheeler's way. The wheeler can also get control of the carriage by moving his horses forward to slacken the traces in front of him. The wheeler controls the pole by urging the near horse ahead if he wishes the pole to go to the right, the off horse if to left. This is the easiest way to control the pole because of the chains attached to the doubletrees and to the carriage. If the carriage is caught on an obstacle move the pole toward the object and back the carriage. Then, without moving the carriage, bring the pole over to the opposite side far enough to clear, and move the carriage out. This will clear easily any object. Learn to guide the near horse, the off horse will follow. Neck rein the near horse in all cases. Use the coupling rein to lead the off horse forward and to the left.

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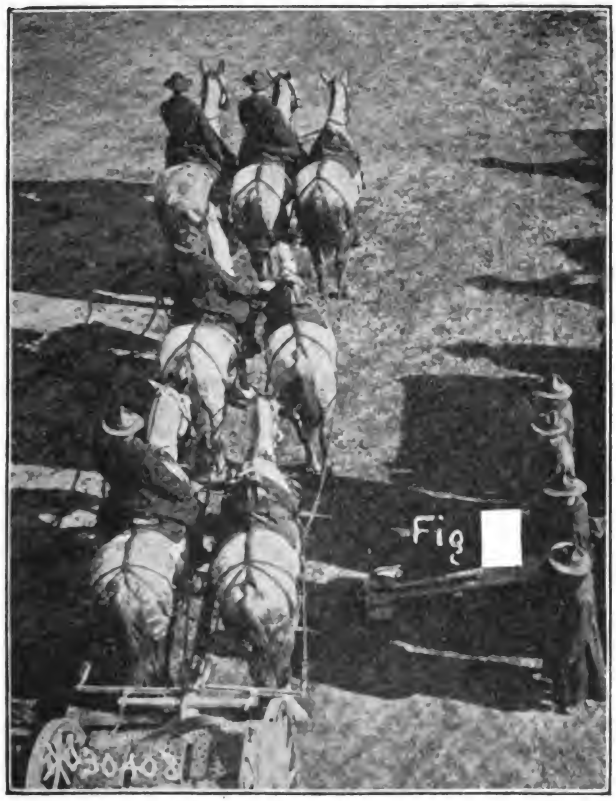
The Limber Turn

The limber turn should be made as follows: As the lead driver comes across the trail he should look back and as soon as the heads of the wheel horses come opposite the end of the lunette, he swings his team sharply (more than 90°) away from the carriage and when opposite the prolongation of the trail, straightens his team to the



rear and halts. The swing driver turns on the same ground as the lead driver. The wheel driver halts his team at the command "Limber Halt" given by the gunner or No. 4. He then passes his team in the direction in which the trail points, turning the limber on an imaginary fixed pivot at the center of the limber axle. This method is easy to execute. The horses, except the wheelers, walk to their positions and there is no lost time in the

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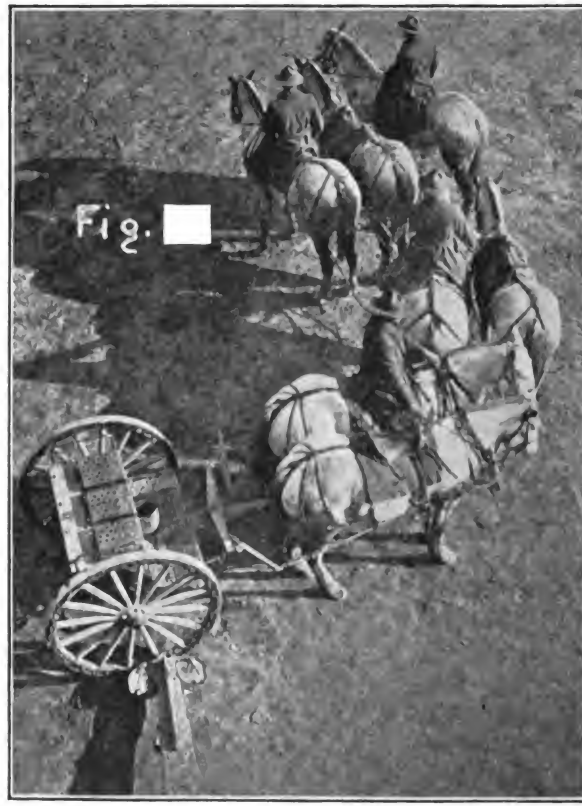
The Brake and its Use

The brake, when properly handled, is most useful and a great benefit to the wheel horses. Wheels should never be locked. The brake should be used so that the wheelers will not be required to help hold back the carriage, in fact a very slight pull by the wheelers is a benefit to them in going down hill. Save the wheel horses as



much as possible, for they have to pull and hold back both, and do considerably more work than the lead and swing. The reason for not locking the wheels is that if they are locked, the wheel will be acted upon by sliding friction in one spot, and this will wear out the tire very quickly.

Gaits

The slow walk is two and one fourth to three miles per hour, the walk four miles per hour. The slow trot is six to six and one half

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miles per hour, the trot six miles per hour. The trot out is ten miles per hour, the extended trot twelve miles per hour and gallop twelve miles per hour.

Marches

The length of marches depends largely upon the character of the road, the number and slope of hills, the condition of the animals, and

the number of hours in harness. Artillery, with animals in good condition, should average twenty miles per day. Six hours in harness should be considered the average time horses should be kept hitched. Standing around in harness is about as tiresome as actual marching. As far as possible marches should be conducted so as to travel fifty minutes and rest ten minutes.

The drill regulations state that under favorable conditions the trot and walk should alternate in the ratio 1 to 3 in regard to time.

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Large horses should travel at a slower trot than light ones. A 1300-pound horse, with good road conditions, can travel at a slow trot (six miles per hour) for a considerable length of time. A slow trot, when the draft is light, does not fatigue an animal, whereas a normal or extended one will have a decided effect. Cannoneers in field batteries should be required to walk on all hills no matter how slight, and only be allowed to ride going down hill or at a gait faster than a walk. Do not let them hold on to the carriages while walking, as this will increase the pull as much if not more than when riding in the carriages.

Field batteries in good condition should be able to make one hundred miles in two days in forced marches with average road conditions. They should be rested two days or only required to make very short marches for the next two days. In the recent Mexican trouble two batteries of the Sixth Florida Field Artillery marched one hundred and twenty-six miles in two days but lost quite a few horses in doing so. This was probably due to the fact that the horses were not hardened. It is a good illustration of the necessity for Battery Commanders to keep their animals in condition at all times.

It is always an advantage, conditions permitting, to finish the march as soon as possible. This is less fatiguing for both men and animals. The drivers should be required to walk for certain periods of the march, as this rests both men and animals. The time of departure or start when other conditions permit, should be regulated by climatic conditions. If the weather is cool, reveille should be at daylight and the march start one hour later. In hot weather when the temperature or sun have detrimental effect on both men and animals, the march should be completed before 9:30 A.M. This will necessitate a start in the dark but a battery that cannot break camp without confusion in the dark should not be rated as a battery.

In the Southern States in mid-summer and in the Philippines the sun affects animals greatly. But the same animals travel rapidly after sunset and from then on to about 9:30 the next morning. While in the Philippines, when permitted to do so, troops that commenced their marches at 4 A.M. had no difficulty in traveling a distance of twenty miles by 8 A.M. They would always make camp between 9 and 10 A.M. Troops that did not start until 7 A.M. or later, caused considerable suffering among their animals in making a twenty-mile march. They could not travel at a gait faster than a walk.

On hills the drivers should lean well forward in the saddle and apply the legs in rear of the girth. If the horse is sluggish the legs

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should be applied vigorously enough to get the desired results. Both horses must be in the collar at all times and by speaking sharply to them the horses are kept at their work. The driver must never pull on the reins when the horse is pulling. The best way to handle a pair on a hill is to sit quietly and give them their heads. The horse in order to pull, sticks his head well forward and down. By pulling on the reins, or moving about on his back the driver disturbs the horse's equilibrium and the result is usually a stalled team.

Going down hill the driver should lean back, grip the horse with his legs, and pull straight back with the reins. Short reins are necessary to control the horse properly. The wheel driver controls the carriage and the lead and swing drivers move out steadily but with slack traces. The brakes should be applied in going down hill but not hard enough to lock the wheels. The heels should be not stuck into the horse's sides as this urges the horse on.

At drill particular attention should be paid to the maintenance of the proper distance at all times. A good test for march discipline is to observe the battery on a road march. If there is no closing up or lengthening out of the column the drivers show the result of good and thorough training. All drivers should keep constantly on the alert so as to anticipate movements. The drivers should maintain the position of the soldier mounted at all times, for slouching in the saddle brings sore backs. Whenever a halt of considerable time is made the limber prop should be lowered in order to take the weight of the pole off the wheelers' necks. Carriages should cover and dress in every formation and movement.

Adjustment of Harness

The importance of the proper adjustment of the artillery harness cannot be overestimated. An artillery horse that cannot be used in draft, due to sore shoulders or neck, is of little value to the battery. The Service is now receiving both breast and steel collars, and while the steel collar is decidedly the better draft implement if properly handled, it is believed the breast collar will give better satisfaction with inexperienced men. It also has the advantage of being able to be adjusted to a horse within a few seconds, while the steel collar may require twenty minutes. A badly fitting steel collar can ruin a horse's shoulder in a few hours' hard draft, while the breast collar will probably cause less damage. There is, however, no excuse for sore shoulders or sore necks with the steel collar, if the collar is properly handled and cared for.

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In all the adjustment of harness, bear in mind that any improperly adjusted part will worry the horse and thus tend to wear him out and cause loss of flesh.

Adjustment of Steel Collar: Collars are issued in the following sizes: 2A, 4A, 4B, 5, 5A, 5B, 6, 6A, 7, 7A, 7B, 8A. The different sizes allow of the numerous adjustments, and practically any horse can be fitted.

The adjustment of Nos. 4A, 5, and 6 collars in inches is given below as a general example of how the different sizes run:

Size	Shortened	Extended	Top Construction Varies	Bottom Buckle Varies	Length Varies
4A	17½	20½	By ½ (3½)	By ¾ (4½) (3¾)	By ¾ (3")
5	19½	22½	By ¾ (4½)	By ¾ (4½)	By ¾ (3")
6	21	24	By ½ (3½)	By ¾ (4½)	By ¾ (3")

The collars are issued as follows: 20 per cent. No. 4A, 30 per cent. No. 5, 40 per cent. No. 5A, 10 per cent. No. 6. If you cannot fit your horse properly with these sizes of collars (which you, in general, cannot), get permission to exchange them for smaller sizes. The length of the collar is measured from the under side of the pad to the top side of the throat of the collar.

If you have no collars for the purpose of determining the correct sizes needed for your battery, make a measuring device to determine the length of the shoulder from top of crest of horse to bottom of throat and send for sizes corresponding to these lengths. You should always have three extra sets of top connections and pads for use in fitting collars.

About 75 per cent. of the horses used in field artillery will use a No. 4, 4A, or 4B collar. The numbered collars, such as No. 5, have quite a curve outward as seen from the front and are used for horses with thick necks, the No. 5A collar is straighter than the No. 5 as seen from the front, and the No. 5B is practically straight and is used for ewe-necked animals. When the horse is in flesh, the collar fitted to him should be the smallest size extended to its maximum. This allows the collar to be taken up and still made to fit the horse if the horse through any cause loses flesh. The collar should be adjusted so that, when in place against the shoulders, the fingers of the hand can be placed between the inside of the collar and the neck and moved in this position from top to bottom of collar with considerable pressure upon the fingers. The throat of the collar should

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allow the fingers, as far as the knuckles, back of the hand horizontal, to be placed between it and the throat of the horse without any pressure on the fingers. To accomplish the adjustment, the ordnance department issues seven sizes of top connections, numbered 0 to 6, and seven sizes of pads also numbered 0 to 6. There are also issued two sizes of buckles for latching the collar. Each collar allows of an increase of length of three inches by unbolting the sliding piece at the top of the sides, and a change of width at the bottom

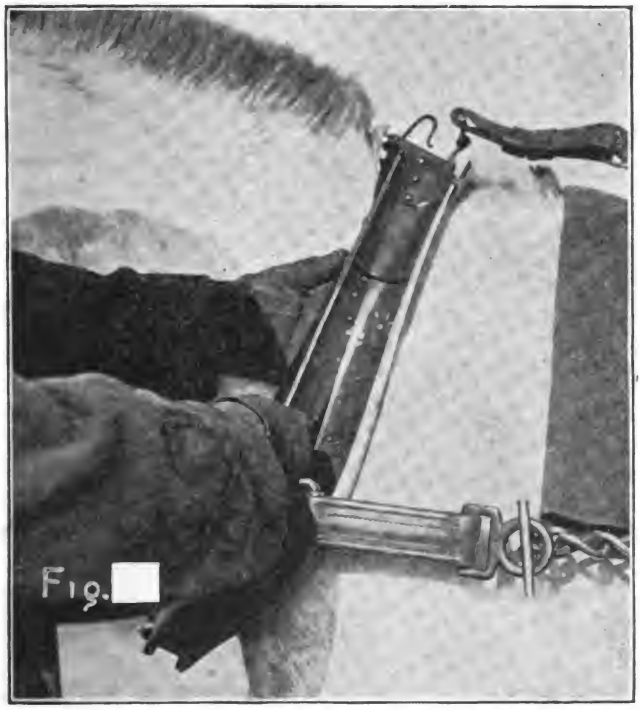

Fig.

of about 3¾ inches by moving the latch bolt and knuckle bolt in different holes. You can also use a different size buckle and increase the width by 1 inch more. For further instructions in fitting collars, especially as to collar pads, and connections see 3-inch Ordnance Handbook No. 1659, page 147. To test the width of the collar, put in place on the shoulder, and pull tight against the side of the neck, while making the test.

Adjustment of Breast Collar: The breast collar should be adjusted as high as possible on the horse's chest without having any tendency to choke him by pressing against the windpipe. This collar can be lowered or raised within narrow limits to relieve galls and

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sores that may occur on new horses when put in hard draft before the shoulders and breast have had a chance to harden.

The best way to tell if the collar is too high is to try the horse out to see if it chokes him. If it doesn't, leave it up as high as possible. Get the line of pull horizontal. Sores are caused by downward pull on the wheel horse's collar and can be prevented by holding-up straps, which besides making the line of pull horizontal also support additional weight put on the horse by the collar chains,

and prevent buckling of the collar. A leather cover can be used to advantage over the collar pad. Keeping the heat off the pad also helps to prevent sores. Some organizations using breast collars have soft leather pieces smooth and soft on the inside, at the neck of collar, which are brought up around the neck piece and fastened to it. This gives a soft, smooth bearing surface which prevents sores. Sole leather is very good to use.

Collar Strap: It should be loose. It is only there to prevent the collar from striking the horse behind the ears when he lowers his head. When the horse lowers his head the strap should be loose enough to prevent his pulling the saddle forward.

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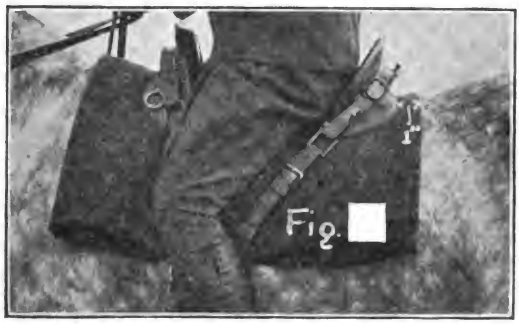
Blanket: The blanket should be carefully folded and examined to see that there are no wrinkles in it. It should be equally divided on both sides of the horse and placed far enough forward so that when the saddle is in place about one inch projects in rear of the



rear end of the side bars of the saddle. All blankets have a tendency to work to the rear, so that after a short distance is traveled, blankets placed in this position will soon be evenly distributed under the saddle.

Saddle: The saddle should be placed on the back so that the front ends of the side bars of the saddle are about the width of three

fingers in rear of the top of the shoulder blades. Before girthing, the blanket should be raised slightly over the withers to prevent pinching by the saddle at that point. In very high withered horses it is often advantageous to use two blankets under the saddle. The girth should never be very tight. After the horse has traveled a

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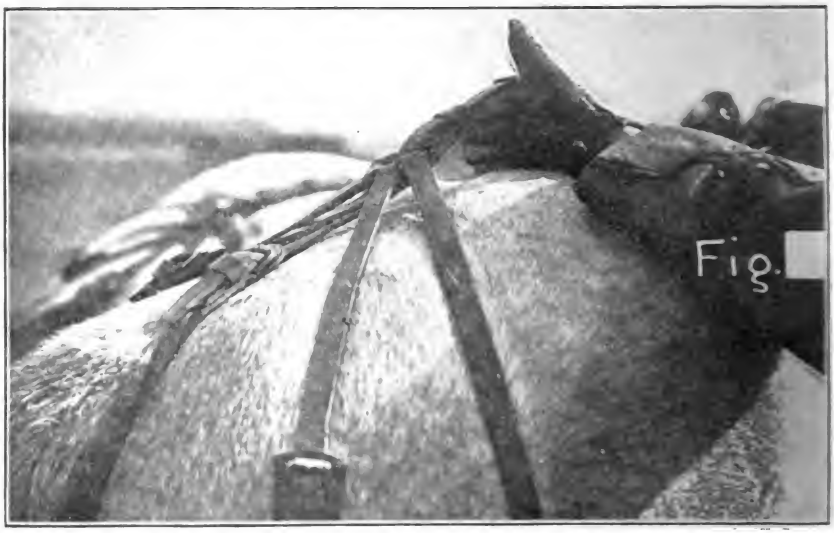
short distance it should be possible to slip the flat of the hand easily between the barrel of the horse and the safe or the cincha ring. The quarter-strap rings should be on the blanket. On level ground there

should be no use for the cincha if the rider sits properly in the saddle. The girth is to keep the saddle on when negotiating up and down grades and difficult country. The cincha should be far enough back to prevent causing sores on the forelegs or underneath the



belly. Cincha safe and quarter-ring safes should be far enough apart to prevent pinching of the flesh between them. Preferably the quarter ring safe should be entirely on the blanket.

For the adjustment of the line of traces, breeching, hip and loin straps, holding-up and holding-down straps, the horse should be in draft, *i. e.*, in the collar.

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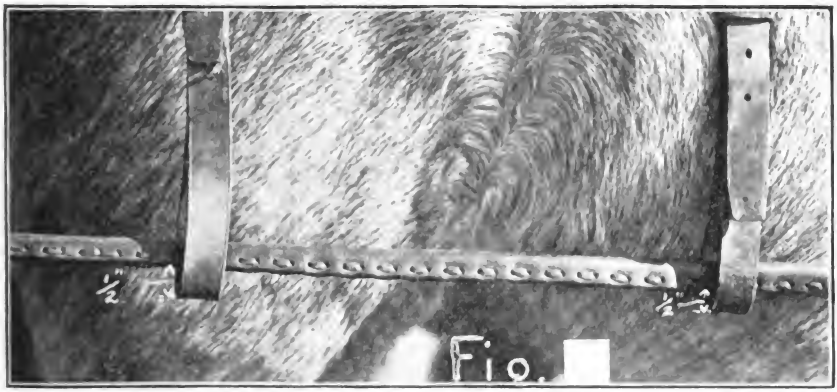
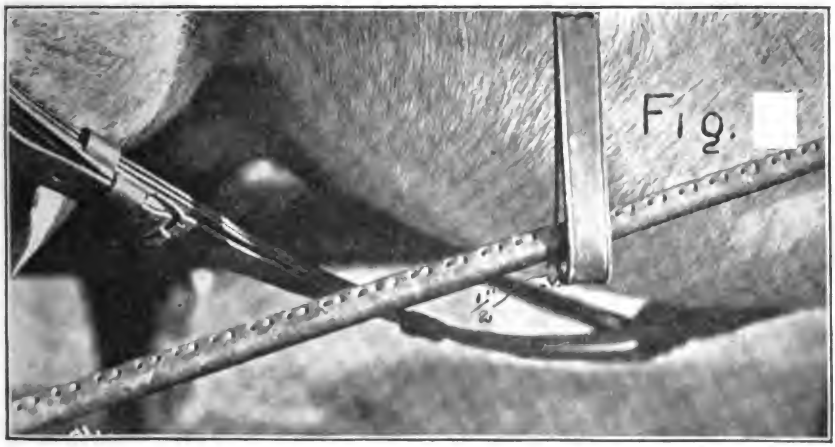
Backstrap: The backstrap should be adjusted so that when the saddle and crupper are in their proper places, the flat of the hand can be held vertically between the backbone and the backstrap. Pull the crupper into place by pulling the backstrap forward and then make the test.



Hip and Loin Straps for Lead and Swing: The hip and loin straps on the lead and swing horses should be adjusted so that when the horses are in draft the trace loops will hang about ½ inch below the traces. Their function is to support the traces when the animals are not in draft. There should be no pressure on these straps when the horses are in draft.



Breeching: The body strap of the breeching is adjusted so that the rear part (part below the tail) is about four inches below the point of the buttocks while the front part where the side straps

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fasten, is adjusted to hang at the height of the stifle. In other words, the body strap of the breeching slants down toward the front. The reason for this adjustment is so as to interfere as little as possible with the movement of the hind legs when the breeching comes in play. If the body strap is too low behind it gives a greater lever arm on the hind legs, and materially interferes with their move-

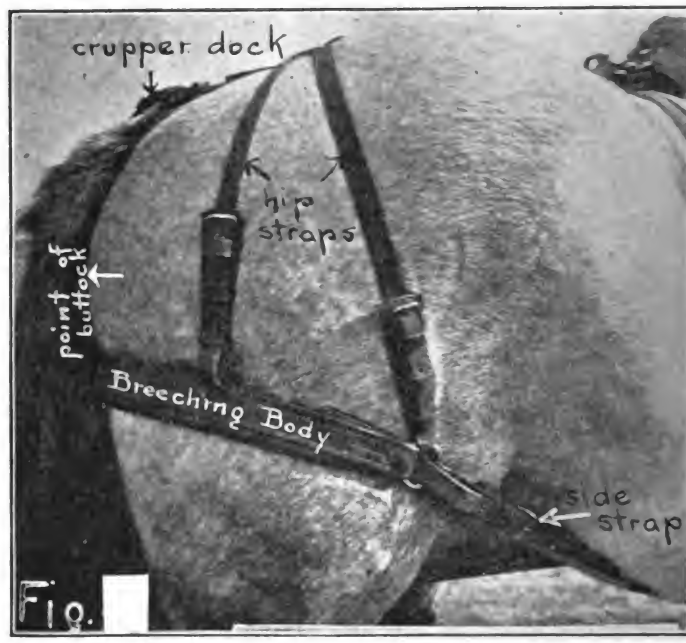

Fig.

ment. If too high most of the strain comes on the hip straps and not on the body strap. Also the side straps bear hard against the barrel of the horse and cause sores. If too low, the front hip strap is always slack and the body is entirely held up by the rear hip strap which is not strong enough to bear all the strain by itself. See that the ring on the body strap hangs at height of stifle. This makes line body strap-side strap a straight line.

Traces: The traces of the lead and swing permit of small changes of length, but as a general proposition it is believed best to have all the traces as short as possible. This is the proper adjustment in all but exceptional cases and prevents having, through carelessness, traces of different lengths placed on the same horse. The average horse in a team can exert a pull on the traces of about 250 pounds. If no holding-down straps are used, the traces pull in a nearly horizontal direction, while the shoulder of the average horse

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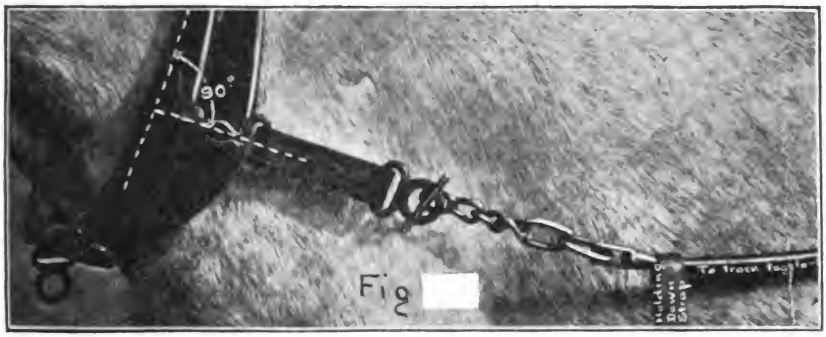
makes an angle of about 16 degrees with the vertical. This means that without the holding-down straps there is an upward pull on the collar in the direction of the shoulder of about 70 pounds. With a properly fitted collar this will choke any horse on a long hard pull and with an improperly fitted collar it will cause sores. The line of pull of the trace where it fastens to the collar should be perpendicular to the line of the shoulder (not to the front face of the collar). This is accomplished by putting the horse in draft and regulating the length of the "holding-down strap" so that this direction is obtained. The wheel traces, due to the downward component of the pull of the swing traces, are pulling on the wheel collars at an angle below



Fig

the perpendicular. This makes the wheel horses sustain considerable pressure on their necks when the team is in draft, besides the weight of the neck yoke, collar, and pole. The pressure due to the downward component of the pull of the swing and wheel traces can be overcome as follows: Get an extra strap with a buckle attached. Run it through the stirrup staple and buckle it around the trace. One such strap is needed for each wheel trace.

Put the team in draft and adjust the length of this strap so that the tugs of the wheel collar are pulling in a direction perpendicular to the slope of the horse's shoulder. The extra pressure placed upon the saddle by this strap has never been known to produce sore backs and the pressure is only exerted when the lead and swing pairs are in draft.

With breast collars no "holding-down straps" are needed, as the direction of pull of the trace takes care of itself. Because the point of attachment of the traces to the collars of the wheel pair is higher than their point of attachment to double tree, there is a downward pull, which must be taken care of. Use holding-up straps with the wheel pair to make the line of pull of the traces from chains

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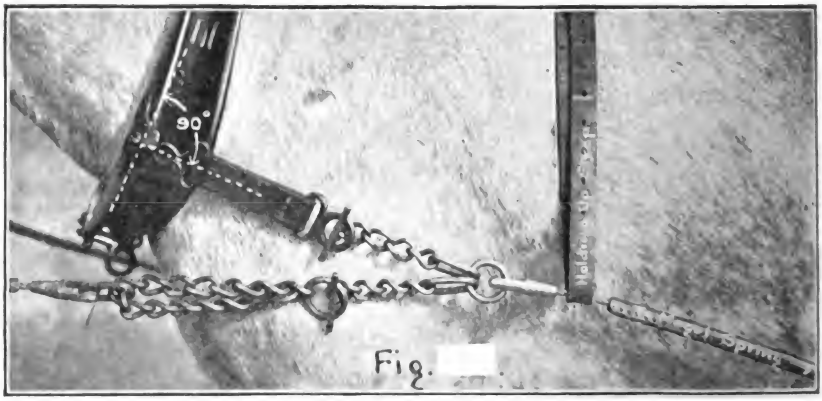
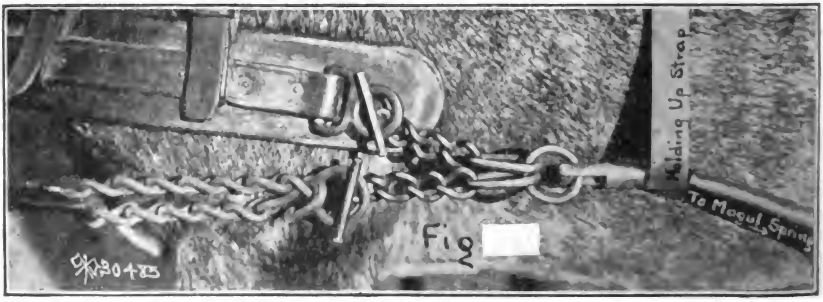
to collar horizontal. The holding-up strap is fastened in the same manner as described above. This prevents downward pull on the neck, and the breaking down of the collar that otherwise would occur.



Traces, Length: There is no adjustment for length of the wheel traces. The lead and swing traces permit of adjustment in length, but in order to prevent traces of different lengths being used on the same horse, it is found best to shorten all traces as much as possible.



Neck Yokes: The breast straps should be so adjusted that the pole is carried horizontally. If too low, the pole has more tendency to thrash, if too high the martingale rubs between the forelegs and produces sores.

Side Straps: The length of the martingale and side straps should be such that when the wheelers are in draft and at an extended trot, the breeching does not interfere with the movement of the hind legs. It should be as tight as possible under these conditions. The position of the safe above the ring in the martingale must be so adjusted that when the horse is holding back it will not

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come in contact with the loop on the cincha. This can be accomplished by the combined adjustment of the side straps and the martingale cincha strap. If not adjusted in this manner it will pull the girth forward and will also catch in the cincha loop and cause constant pressure on the body strap of the breeching and tend to rip or break the loop of the cincha. A rough test for the combined adjustment of the martingale and side strap is to put the wheeler in the collar, and pull back on the breeching body. If properly adjusted you should be able to place the hand in between the body

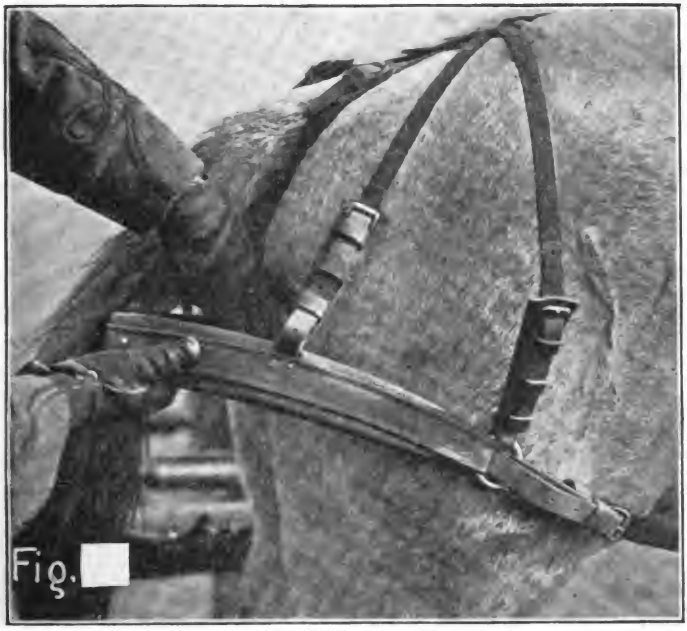

Fig.

strap of the breeching and the horse's buttock, the fingers extended from thumb to little finger so that the thumb is toward the body strap, and the little finger on the horse's buttocks. This will give a clearance of about eight inches between the body strap of the breeching and the horse's buttocks. Adjust by the combined adjustment of the side straps and the martingale, keeping in mind that the D ring of the martingale should be far enough through the loop on the cincha to prevent its being caught in the loop when the horse is back in the breeching. The martingale can be adjusted by means of the martingale cincha strap; the side straps by means of the buckle and the holes in the straps.

Bridle (snaffle bit): The crown piece and brow band should be long enough to prevent chafing at the base of the ears. Pressure

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here will cause sores and the horse will become head shy and hard to bridle. It is often found that with large-headed horses these parts are not long enough and new ones should be made to replace them. The cheek pieces should be so adjusted that the snaffle bit fits snugly in the corners of the mouth but does not wrinkle them. This places the bit about 1 to 1½ inches above the tushes. In mares where there are no tushes the bit should be about 2 to 2½ inches above the corner teeth. If the bit is too low it will hit against the teeth and cause pain and fretting. The throat latch should be so loose that there is no pressure on the horse's throat. The coupling rain should be long enough so that in the turn to the right when the off horse is ahead of the near horse there will be no pull on the off horse's mouth. Also the adjustment should be such as to permit the off horse lowering his head to the right and grazing.

Stirrup Strap: To assemble the stirrup strap properly stand on the side of the horse on which the stirrup is to be placed, facing the horse's head. Pass the strap through the hole in the top of the stirrup, the rough or flesh side up. Holding the strap as shown in the cut, give the buckle end one half turn away from the horse, thereby bringing the standing loop up. Pass the end of the strap through the loop keeping the smooth or hair side up. Then run the strap through the stirrup staple from the top and carry it to the buckle. The cut shows the adjustment of the near stirrup.

The final and true test of the adjustment of the harness is to put the team into draft and observe the work of each horse of the team. If properly adjusted, the horses will be comfortable and will be able to work quietly and easily for any length of time.

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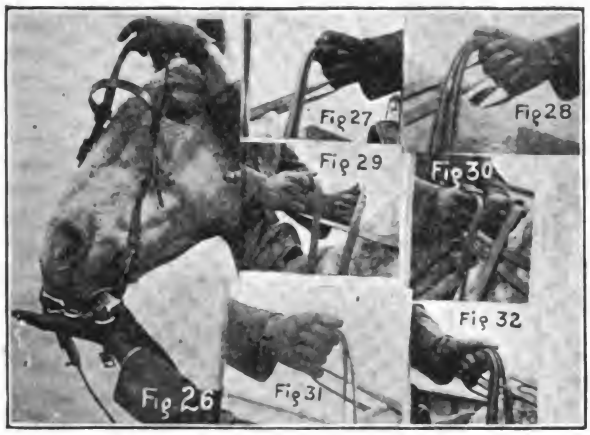

Figure 26. Method of supporting the bit in bridling and unbridling. This will prevent the bit from striking against the tushes.

Figures 27–32. Methods of holding reins of single and double bridle in either or both hands.

Figure 27. Single reins held in right hand. Off rein enters beneath little finger, near rein, between little finger and third finger. Both reins leave the hand between the thumb and forefinger. Bight falls to near side.

Figure 29. Single reins held in both hands. Each rein enters the hand beneath little finger and comes out between the thumb and forefinger. Bight falls to the off side.

Figure 31. Single reins held in left hand. Near rein enters the hand beneath little finger, off rein between the little finger and third finger. Both reins leave the hand between the thumb and forefinger. Bight falls to the off side.

Figure 28. Double reins held in right hand. The reins enter the hand as follows: Off snaffle beneath little finger; off curb between little finger and third finger; near curb between second and third fingers; near snaffle between forefinger and second finger. All reins leave the hand between the thumb and forefinger bight falling to the near side.

Figure 30. Double reins held in both hands. The reins enter the hands as follows: curb beneath the little finger; snaffle between the little finger and third finger, both reins leave the hands between the thumb and forefinger, bight falling to the off side.

Figure 32. Double rein held in left hand. The reins enter the hand as follows: near snaffle beneath the little finger; near curb between little finger and third finger; off curb between second and third fingers; off snaffle between forefinger and second finger. All reins leave the hand between the thumb and forefinger, bight falling to the off side.

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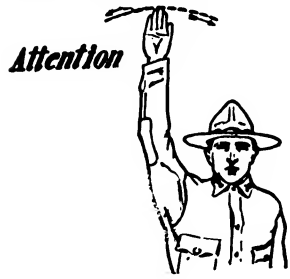
Mounted Drill

The contents of this chapter explain details of paragraphs of the D. and S. R. F. A.

All paragraph numbers in this chapter refer to the corresponding paragraphs in D. and S. R. F. A.



Commands. 501–506

Chiefs of section will supervise the gait and direction of march of their sections, therefore they must promptly translate the battery commander's arm signal to the proper verbal commands in addition to repeating the arm signal. To insure proper execution of the maneuver, without hesitation, this must be demanded of the chiefs of section.

Pairs in draft require the undivided attention of the drivers at all times, therefore, drivers should never look for the battery commander's arm signal but should receive all of their commands from their chiefs of section.

In changes of formation in which the section acts as a unit the caisson corporal's only duty is to supervise the movement of his carriage; he does not repeat the commands, except when in order in flank column. In movements in which the carriages of a section move independently of each other, both the chief of section and the caisson corporal give the arm signal and verbal command for the movement of their respective carriages.

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The arm signal is the best means of delivering a command in Mounted Drill. It should be made slowly and accurately. Care should be taken to clearly distinguish between similar signals, *e. g.*, "Right Oblique" and "Right Front Into Line."

When giving arm signals the battery commander should always place himself so that he can be easily seen by all chiefs of carriage and should allow proper interval between the preparatory command and the command of execution. All arm signals by the battery commander should be preceded by the whistle signal of "Attention," thereby attracting the attention of all chiefs of carriage. The chiefs of carriage have such a limited time in which to repeat the command that they must be required to sound off instantly so that all drivers will have received the preparatory command before the command of execution is given.

For purposes of drill, demand that all chiefs of carriage use the arm signals whenever possible, paying particular attention that they are in exact compliance with the D. and S. R. F. A.

In changes of formation in which it becomes necessary for certain carriages to halt at the command of execution the chief of carriage or the chief of section, if the section acts as a unit, should command "1. Section (piece or caisson) 2. Halt," giving his command of execution simultaneously with that of the battery commander. This will put the drivers on the alert and prevent the jamming of carriages and pairs.

All sections automatically dress without command on the point of rest in all changes of formation from column to line executed at the walk, remaining at the dress until "Front" is given by the battery commander. The guide is always announced when in order in flank column.

When at a halt chiefs of carriage should always warn the drivers to gather the horses and take up all the slack in the traces before a command of execution.

Do not allow the section to trot in order to make up lost distance. Lost distance should always be regained by extending the walk.

Whenever a carriage or section maintains its gait and direction during a change of battery formation, the chief of carriage or section cautions "Continue the March." If the carriage or section is at a halt and is to remain halted he cautions "Stand Fast." These are warning commands and should always be used as precautionary signals for the drivers.

When all sections or carriages simultaneously change direction through 90° the proper command to be given by each chief of carriage is "By the Right (Left) Flank." The command "Column

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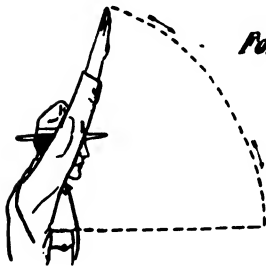
Right (Left)" is used in only two instances: 1st, when a change of direction is executed by the entire battery in column formation; 2d, when a section changes direction in column, the rear carriage following in the tracks of the leading carriage of its section (*e. g.*, in executing "Right Into Line" from section column).

Do not use the command "Right (Left) Wheel" and never allow the command "Column Right (Left)" to be given by chiefs of carriage in movements which require all carriages to change direction simultaneously.

The command "Countermarch" is improperly used when the battery is in double-section formation. The command should be "Left About."



Forward

To March to the Front

Par. 522. "1. Forward (Gather your Horses). 2. March."

In executing this movement the command "Forward" should always be followed by the cautionary command "Gather your Horses," until the drivers have become accustomed to doing so without being reminded.

To Halt

Par. 523. "1. Battery, 2. Halt."

To Halt

Three yards is halting distance from a walk. All traces should be taut after the carriages have completed the halt. This can be accomplished by causing the pairs of each individual team to come to the halt in the order: wheel, swing, lead. This means that the lead and swing must give the wheelers time to halt the carriage. Chiefs of section should give the preparatory command in ample time to warn the drivers.

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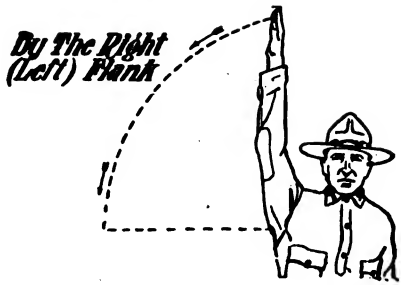
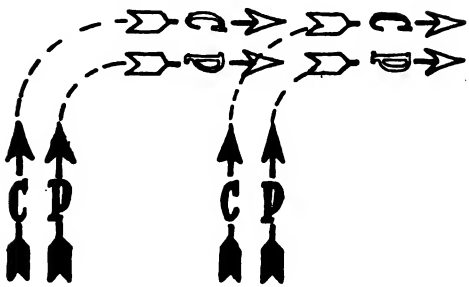
To March by the Flank

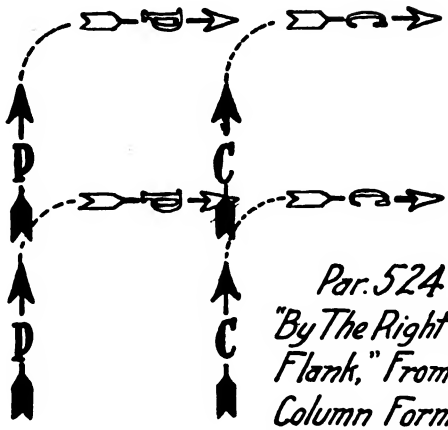
Par. 524. "1. By the Right (Left) Flank. 2. March."

The chiefs of section command "By the Right (Left) Flank." If the section is in flank column formation the caisson corporals also repeat the command.





Par. 524
"By The Right (Left) Flank," From Double Section Line Forms Double Section Column To The Right (Left).



Par. 524
"By The Right (Left) Flank," From Flank Column Forms Order In Line To The Right (Left).

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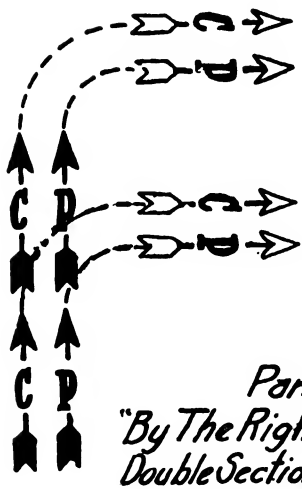
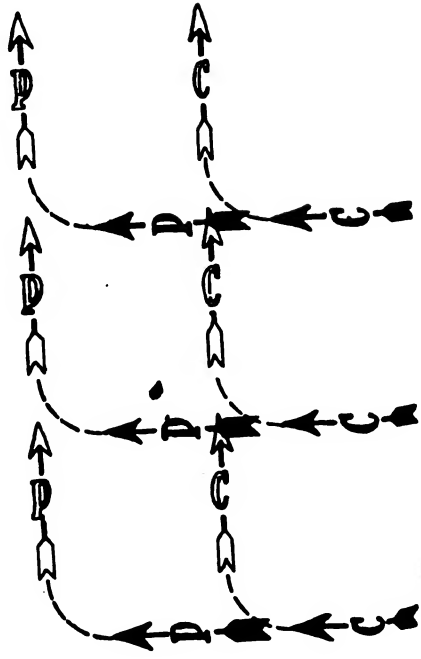


Par. 524
"By The Right (Left) Flank," From Double Section Column Forms Double Section Line To The Right (Left).

Par. 524
"By The Right (Left) Flank." From Order In Line Forms Flank Column To The Right (Left).

Par. 525. Battery in line with closed intervals. Demand that the chiefs of section give the preparatory command, "By the Right (Left) Flank," at the same time as the chief of section next on the indicated flank gives his command of execution; also insist upon the command of execution being given promptly enough, for it is far better to move out a trifle soon than to lose distance. This movement should never be executed from a trot because it necessitates a decrease in gait of two degrees by all sections except the one on the indicated flank, and an increase in gait of two degrees, during which time it would be impossible to avoid losing distance.



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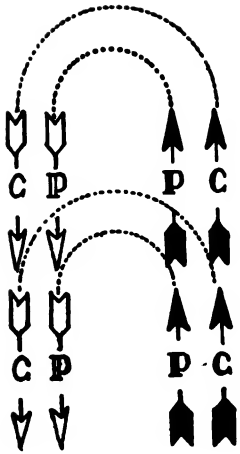
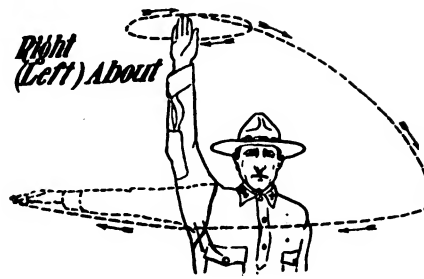


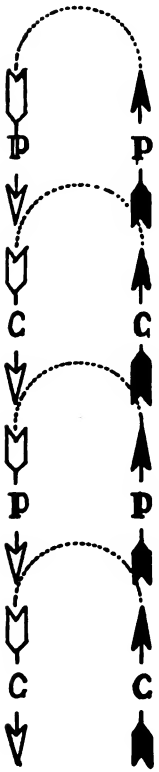
Par. 526
"Left (Right) About,"
From Double Section
Column Forms Double
Section Column To
The Rear.



To March to the Rear

Par. 526. "1. Right (Left) About. 2. March."

When the movement is completed all sections and carriages should cover immediately, and, if the movement has been executed properly, they will be marching on a track parallel to, and at an interval of 12 yards from, their former track. Chiefs of section and caisson corporals command "Right (Left) About."



Par. 526
"Left (Right) About," From
Section Column Forms
Section Column To The
Rear, The Order Of
Carriages Within Each
Section Being Reversed.

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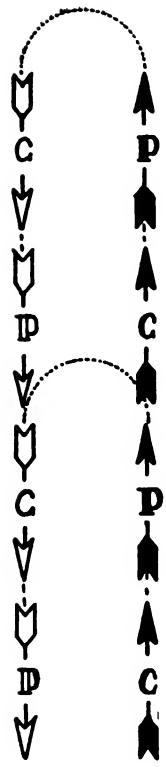
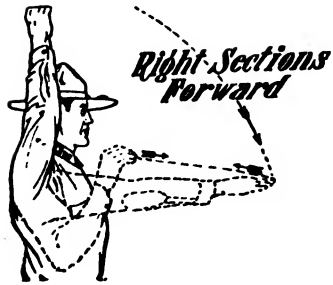


Par. 526
"Countermarch," From Section Column Forms Section Column To The Rear, The Order Of Carriages Within Each Section Remaining Unchanged.

Par. 526. "1. Countermarch. 2. March."

This movement can be executed only when sections are in section column. The entire section acts as a unit, the rear carriage following in the track of the leading carriage. Chiefs of section command "Counter-march."

The movement having been completed, all sections and carriages should cover immmediately and, if executed properly, will be marching on a track parallel and at an interval of twelve yards from, their former track.



Right Sections Forward

Par. 527. "1. Right Sections Forward. 2. March."

If the movement is executed from a halt the chief of the right section of each platoon commands "Forward," the chief of the left section of each platoon cautions "Stand Fast." If an increase of gait has been announced the right sections will immediately move off at the increased gait, the chiefs of the left sections cautioning "Continue the March." The effect of this movement will be lost unless the right sections dress to the right in moving out and after they have increased the gait, so that they will reach their position in line simultaneously.

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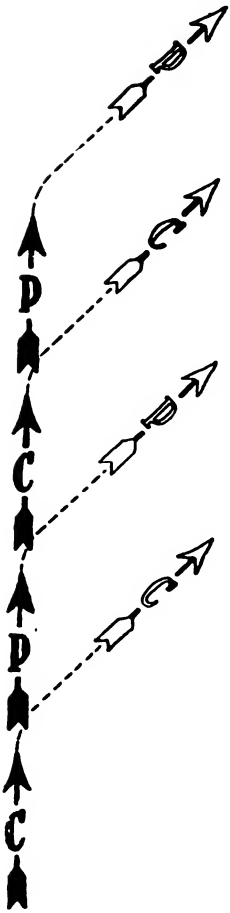
To March Obliquely

Par. 529. "1. Right (Left) Oblique. 2. March."

When the sections are in double section formation the carriages on the flank toward which the oblique is being made are one half horse's length in advance of the other carriages and when the second oblique is made to the opposite direction they are again automatically aligned. If the second oblique is made in the same direction, the outside carriage must increase the gait in order to come on line.

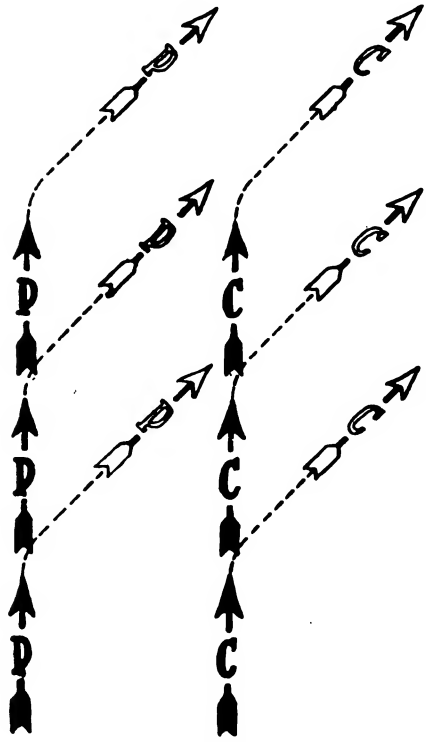
All chiefs of section command "Right (Left) Oblique."

If executed from section column or order in line, care should be taken that the rear carriage of each section immediately moves to the oblique and does not follow in the track of the preceding carriage.



Par. 529

"Right (Left) Oblique." From Section Column Places The Carriages On The Oblique As Shown.



Par. 529

"Right (Left) Oblique." From Flank Column Places The Carriages On The Oblique As Shown.

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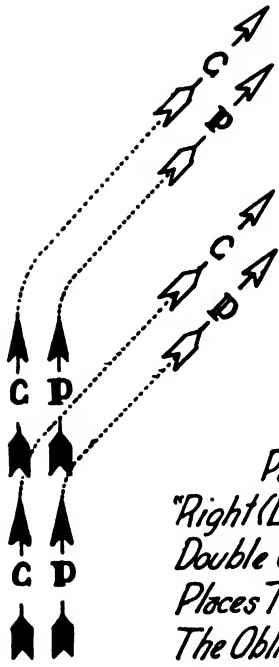
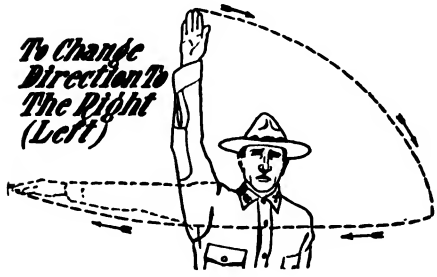


Par 529
"Right (Left) Oblique" From Double Section Column Places The Carriages On The Oblique As Shown.

To Change Direction

Par. 530. "1. Column Right (Left). 2. March."

The chief of the leading section commands "Column Right (Left)." All other chiefs of section caution "Continue the March" if executed from a walk, or "Forward" if executed from a halt, and then give the command "Column Right (Left)" when their section arrives at the pivot.



During the execution of this movement there is a great tendency to increase or decrease the interval. If executed from flank column formation the tendency is for the carriages on the outside of the turn to close in; if executed from double section formation the outside carriages tend to increase the interval. In executing this movement from flank column formation the carriages on the outside of the turn will not increase their gait until the inside carriages of their respective sections arrive at the pivot.

Par. 531. "1. Battery Right (Left) Wheel. 2. March."

The chief of the pivot section commands "Column Right (Left)," all other chiefs of section command "Column Half-Right (Left)" and, when their sections have arrived opposite their places in the new line, again command "Column Half-Right (Left)." Insist upon all sections maintaining their proper interval at all times during this movement.

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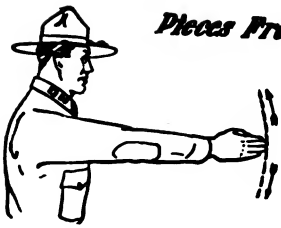

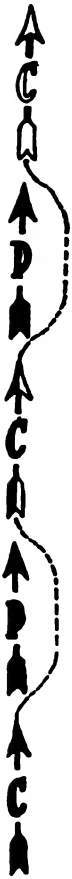

To Execute a Passage of Carriages

Par. 532. "1. Pieces (Caissons), Front. 2. March." When executed from Section Column.

If the command be "Caissons Front" the chiefs of section command "1. Piece, 2. Halt," if executed at a walk; if executed at an increased gait the chief of section will decrease the gait of the piece by one degree. The caisson corporal will place his carriage in front of the piece by a series of obliques, passing to the right of the piece at an interval of two yards. When the command is "Pieces Front," the chief of section being with the caisson, the lead driver of the piece is responsible for the piece executing the movement correctly.

Par. 532
"Pieces (Caissons) Front,"
From Section Column
Forms Section Column
To The Front, The Order
Of Carriages Within
Each Section Being
Reversed.

To Close or Extend Intervals in Line

Par. 533. "1 On (such) section. 2. To (so many) yards. 3. Close (extend) intervals. 4. March."

The indicated section moves straight to the front, the chief of section warning "Continue the March." The chiefs of section on the right of indicated section, when closing, command "Left Oblique" and, having arrived at the indicated interval, command "Right Oblique," placing themselves abreast of the directing section. The sections on the left of the indicated section similarly execute the movement. Insist upon all carriages making true obliques and maintaining their proper intervals.

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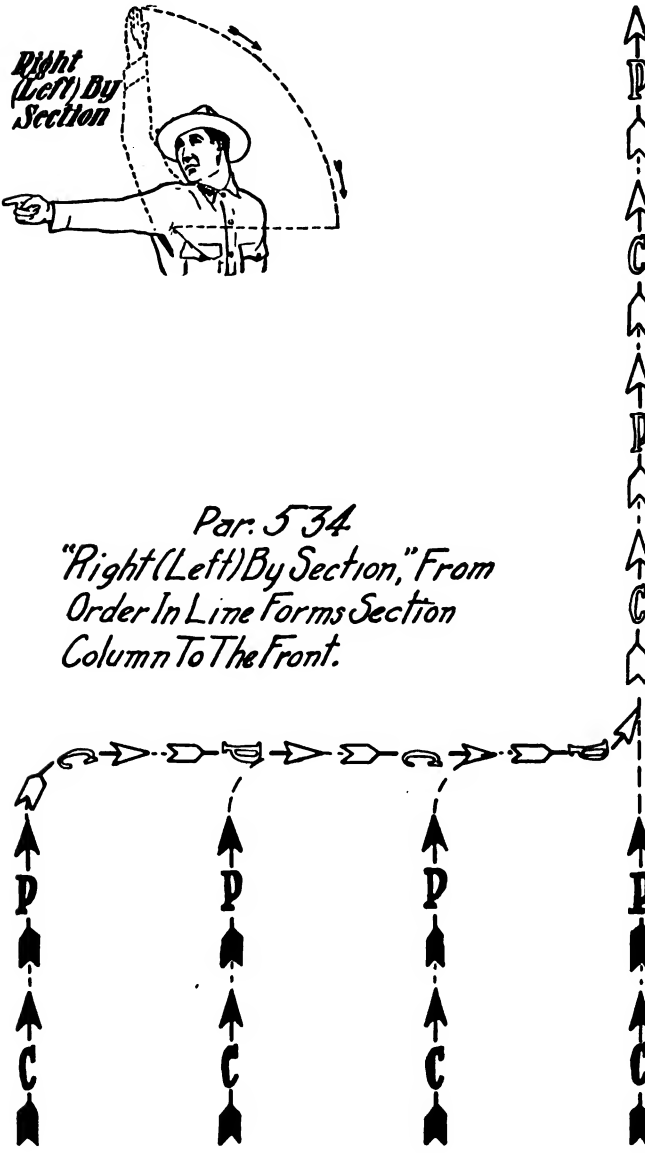
To Form Section Column to the Front from Line

Par. 534. "1. Right (Left) by Section. 2. March."

When in order in line the movement is successive, the section on the indicated flank beginning the movement; all other sections moving out so as to follow in column at the proper distance. If executed from a walk all sections except the one on the indicated flank come to a halt and then resume the march, individually, so as to follow in column. Practice is necessary to avoid losing distance in the execution of this movement; chiefs of section should be warned to time carefully their moving out. A good guide to follow in this respect is to move out each section when the wheel of the piece or caisson of the leading carriage next on the directing flank has come abreast of the lead horses of the leading carriage.

Par. 534
"Right (Left) By Section," From Order In Line Forms Section Column To The Front.



The chiefs of section direct their sections by commanding "Column Right (Left)" and then "Column Left (Right)" after having arrived at the pivot.

When the battery is in double section line at normal intervals all sections simultaneously change direction to the right or left and follow in column. All chiefs of section command "By the Right (Left) Flank," except the chief of the right (left) section, who commands "Forward."

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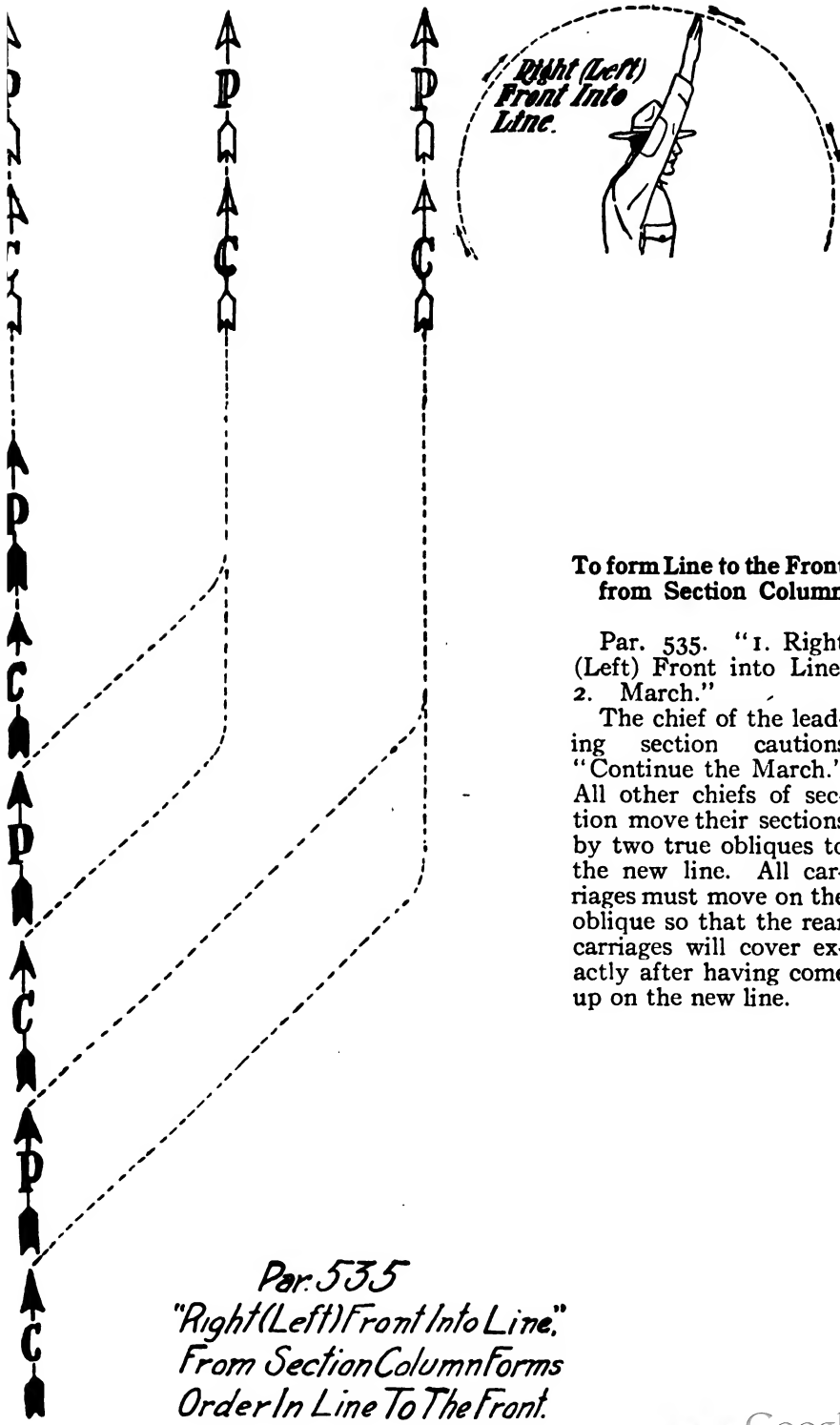

To form Line to the Front from Section Column

Par. 535. "1. Right (Left) Front into Line. 2. March."

The chief of the leading section cautions "Continue the March." All other chiefs of section move their sections by two true obliques to the new line. All carriages must move on the oblique so that the rear carriages will cover exactly after having come up on the new line.

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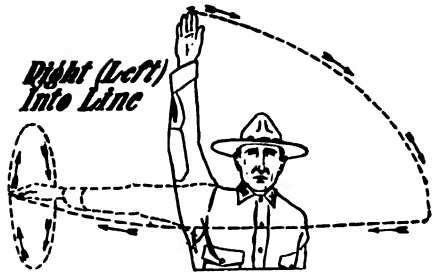
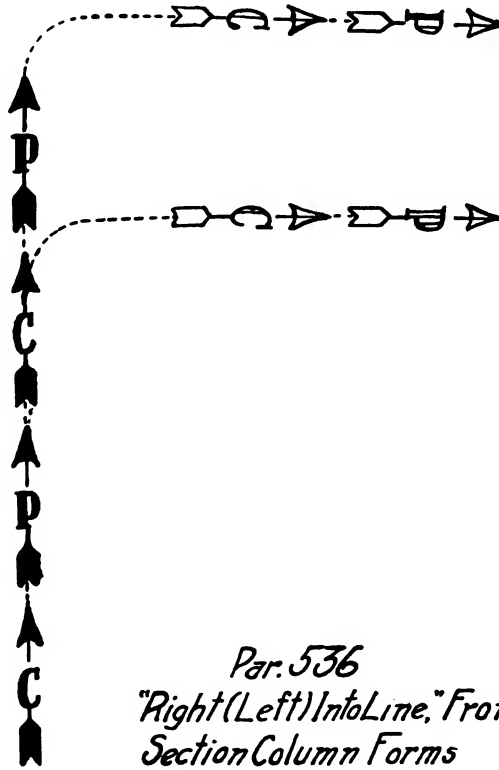


To Form Line to the Flank from Section Column

Par. 536. "1. Right (Left) into Line. 2. March."

The chief of the leading section commands "Column Right (Left)"; all other chiefs of section caution "Continue the March" and then command "Column Right (Left)" when the piece (caisson) wheels of the leading carriage of the preceding section are on the pivot. The tendency in the execution of this movement is to reduce the interval to less than seventeen yards, due to the failure of the chiefs of section to get their commands out promptly.

To form line at closed intervals the battery commander will indicate the desired interval by verbal command after having given the arm signal for closing. Intervals of less than six yards can conveniently be indicated by extending the thumb and fingers of the hand, each finger representing one yard. A prearranged whistle signal may also be used.



Par. 536
"Right (Left) Into Line," From
Section Column Forms
Order In Line To The
Right (Left).

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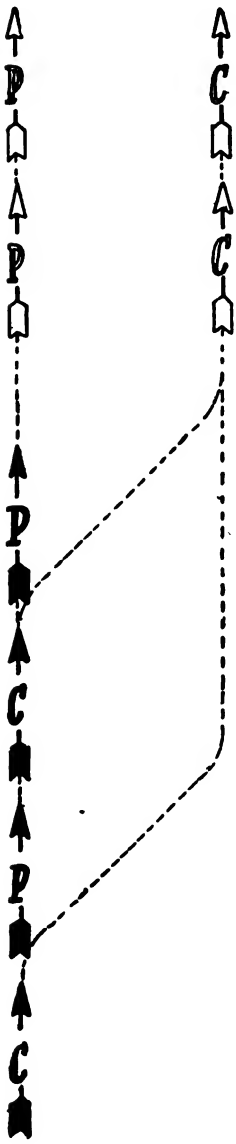
To Form Flank Column from Section Column

Par. 539. "1. Flank Column Right (Left) Oblique. 2. March."

The chief of the leading carriage in each section cautions "Continue the March"; the chief of the rear carriage commands "Right (Left) Oblique," and then "Left (Right) Oblique" when seventeen yards' interval has been gained. All carriages obliquing should execute the second oblique simultaneously and cover promptly.



Par. 539
"Flank Column Right (Left) Oblique," From Section Column Forms Flank Column To The Front.

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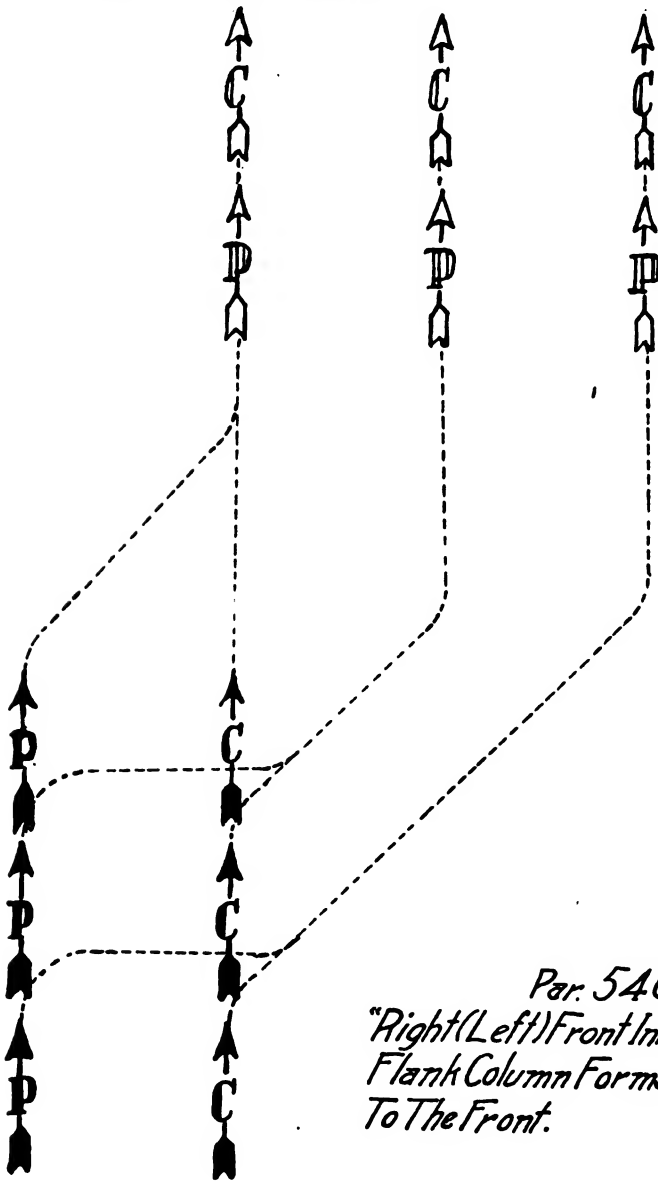
To Form Line to the Front from Flank Column

Par. 540. "1. Right Front into Line. 2. March."

The right leading carriage moves straight to the front; the left leading carriage executes a right oblique and follows in the track of the right carriage. All other chiefs of carriage on the right of the column command "Right Oblique." The chiefs of section on the left command "By the Right Flank," each section forming section column. Section columns having been formed, the chiefs of section command "Column Half-Left."



Par. 540
"Right (Left) Front Into Line," From Flank Column Forms Order In Line To The Front.

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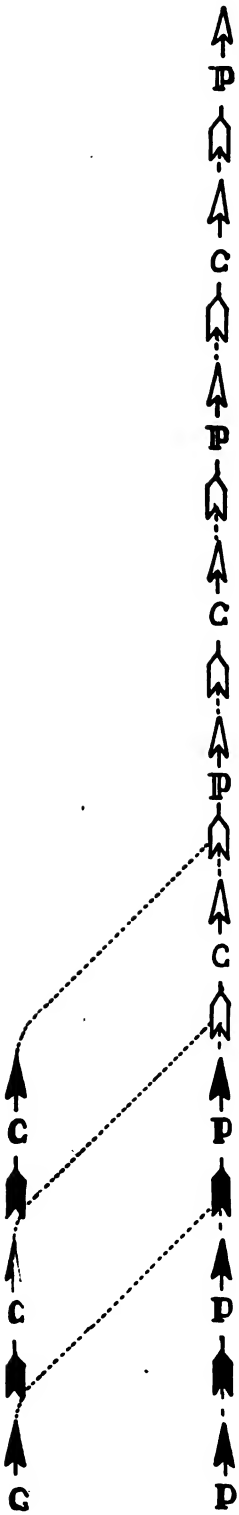

Par. 542. "Pieces (Caissons) Front," From Flank Column Forms Section Column To The Front.

To Form Section Column from Flank Column

Par. 542. "1. Pieces (Caissons) Front. 2. March."

The movement is successive. The chiefs of the designated carriages command "Forward" or caution "Continue the March," as the case may be; the chiefs of the other carriages command "Right (Left) Oblique" and then "Left (Right) Oblique," following in the track of the preceding carriages at the proper distance.

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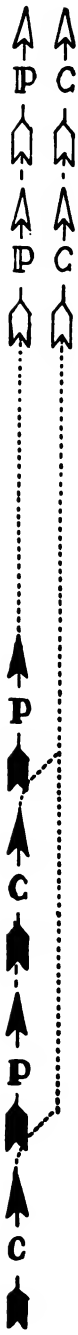
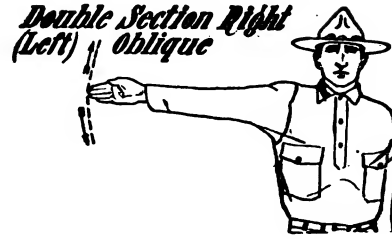


Par. 543
"Double Section Right (Left) Oblique," From Section Column Forms Double Section Column To The Front.



To Form Double Section and to Resume the Previous Order

Par. 543. "1. Double Section. 2. Right (Left) Oblique. 3. March." Being in line or in section column.

The chief of the leading carriage of each section commands "Forward" or cautions "Continue the March" (if the movement is not executed from a halt); the chief of the rear carriage of each section commands "Right (Left) Oblique" and then "Left (Right) Oblique," placing his carriage abreast of the leading carriage of his section and at an interval of two yards from it.

If in section column, all carriages in rear of the leading one close upon the carriages which precede them in the column at the gait of the carriage which obliques. The increase of gait is taken up simultaneously by all carriages.

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Par. 544. "1. Pieces (Caissons) Front. 2. March." Being in double section line or double section column, to resume the previous order.

If in column the movement is successive, the chief of the designated carriage commanding "Forward" if at a halt. "Continue the March" if moving at a walk and no increase of gait is announced.

If an increase of gait is announced the command "Trot" is given. The chief of the other carriage in each section commands "Right (Left) Oblique" and then "Left (Right) Oblique," giving the second at the proper time to follow the directing carriage at two yards' distance.

The remaining sections in the column execute the movement in the same manner. If no increase in gait is announced all carriages, except the directing (designated) carriage of the leading section, decrease the gait by one degree.

If in line the movement is executed simultaneously by all sections.

Par. 544.
"Pieces (Caissons) Front,"
From Double Section Column
Forms Section Column To
The Front.

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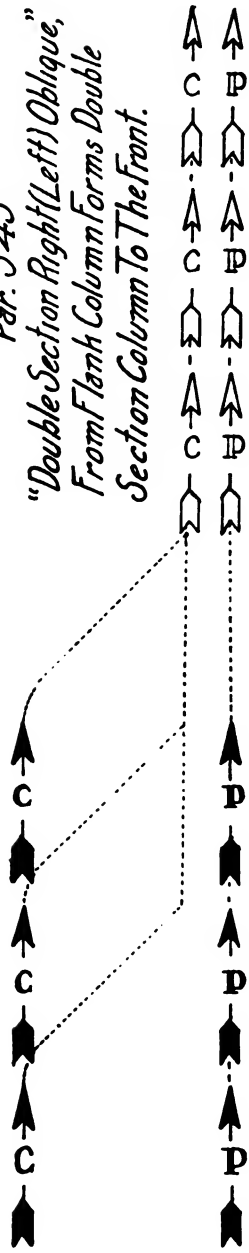

Par. 545. "1. Double Section. 2. Right (Left) Oblique. 3. March." Being in flank column to form double section column.

The chiefs of carriage on the right (left) of the column caution "Continue the March" or if no increase in gait is announced they give the command to decrease the gait by one degree. The chief of the leading carriage on the right (left) of the column should give a warning signal to the chiefs of carriage in rear before he halts, in order to prevent jamming and to effect a simultaneous halt by all carriages.

The chiefs of carriage on the left (right) of the column command "Right (Left) Oblique" and then "Left (Right) Oblique," giving the second command so that their carriages will move up abreast of the right (left) carriages at two yards' interval.

Insist that all carriages dress while obliquing, change direction to the front, and halt simultaneously.

"1. Flank Column. 2. Right (Left) Oblique. 3. March." Being in double section column to form flank column.

The chiefs of carriage on the left (right) of the column caution "Continue the March," or if no increase in gait is announced give the command "To decrease the gait by one degree." If the movement is executed from a halt or walk the chief of the leading carriage on the left (right) should give the signal of attention before halting so that all carriages will execute a smooth orderly halt and preserve proper distance.

The chiefs of carriage on the right (left) command "Right (Left) Oblique" and then "Left (Right) Oblique," giving the second command so as to move up abreast of the left (right) carriages at seventeen yards' interval.

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To Form Flank Column to the Front from Order in Line

"1. By the Right (Left) Flank. 2. Column Left (Right). 3. March."

The leading carriage of the right (left) section moves straight to the front, maintaining its gait, the rear carriage of the right (left) section executes "By the Right (Left) Flank" and "Column Left (Right)," immediately increasing its gait by one degree until it has arrived abreast of the other carriage of its section. The remaining sections execute "By the Right (Left) Flank" and "Column Left (Right)," executing the "Column Left (Right)" on the same ground as the right (left) section.

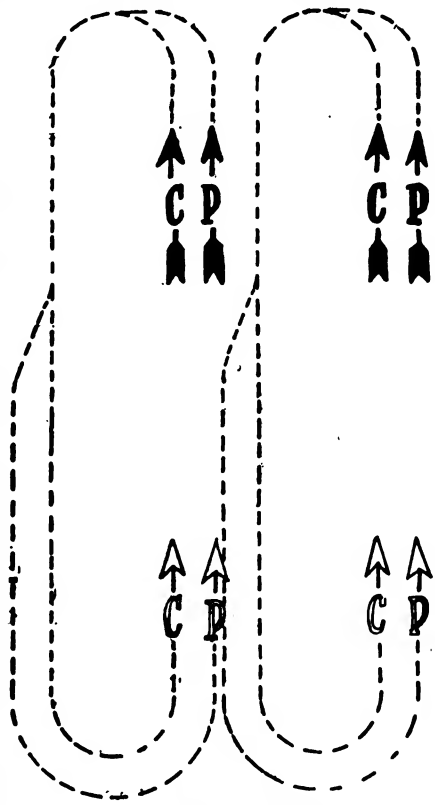
Rules 1 and 2 do **not** apply.

Unlimbering and Posting the Limbers

Par. 551–559. At the command for "Action" the limbers come under the command of the first sergeant who gives the appropriate commands to move the limbers to the rear.

Limbers habitually limber and unlimber at the trot; in limbering they come down from the trot to the walk, individually, as the heads of the lead pairs come abreast their respective lunettes preparatory to making the "Limber Turn."

Limbers "inclining" change direction by about twenty-two and one half degrees (one quarter of a right angle) to the right or left of their original front.



Par. 559
"Action Front," From Double Section Line Showing Method Of Posting Limbers.

The lead driver, in the absence of a chief of section, is in command of the piece limber; he repeats verbally all commands and is responsible for the proper guidance of his limber.

When the battery is formed for action and enters from the flank it is usually advisable to place the piece on the side of the column

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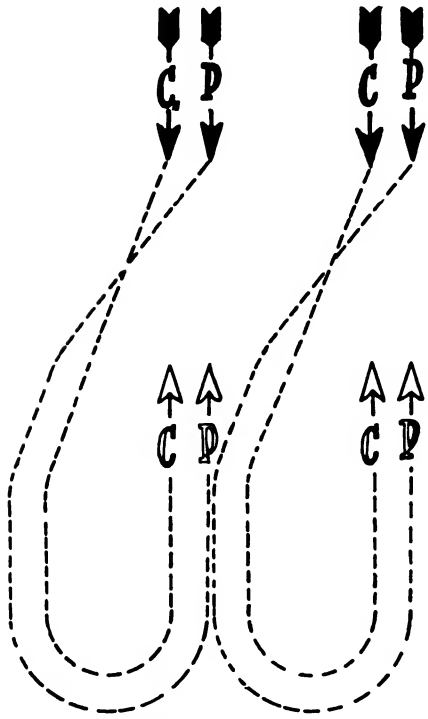
towards which fire is to be delivered, since this will allow some additional time to prepare the piece for action while the caisson is being established in position.

Cannoneers should be warned to work with the greatest rapidity in unlimbering, so that the limbers can move to the rear as soon as possible.

To Fire to the Front

Par. 559. "Action Front." Being in double section line, caissons on the left of their pieces.

When all carriages have been unlimbered the First Sergeant commands "Limbers Left About. Trot." The caisson corporals repeat the "Left About" (as prescribed for a section in double section formation, maintaining the two-yard interval, the outer limber increasing its gait by one degree until it has arrived abreast of the inner limber), and move straight to the rear, dressing to the right. When they have moved forty yards to the rear the First Sergeant commands "Left About" and halts the limbers so that the heads of the lead horses will be twenty-five yards from the rear of their respective sections. This is measured from the heads of the lead horses or the end of the pole to the rear of the caisson.



Par. 560.
"Action Rear," From Double Section Line Showing Method Of Posting Limbers.

To Fire to the Rear

Par. 560. "Action Rear." Being in double section line, caissons on the right of their pieces.

When all carriages have been unlimbered the first sergeant commands "Incline to the Right." The caisson corporals repeat the command. The drivers of the pieces execute slow trot or walk in order that the piece limber will move out at a slower gait until the caisson limber has preceded it, at which time the piece limbers, without command, take up the trot, oblique to the right and then to the left, placing themselves abreast of and on the right of the caisson limbers. They then conform to the direction and gait of the caisson.

When the limbers have moved forty yards to the rear the First Sergeant commands "Left About" and the limbers take post as in "Action Front."

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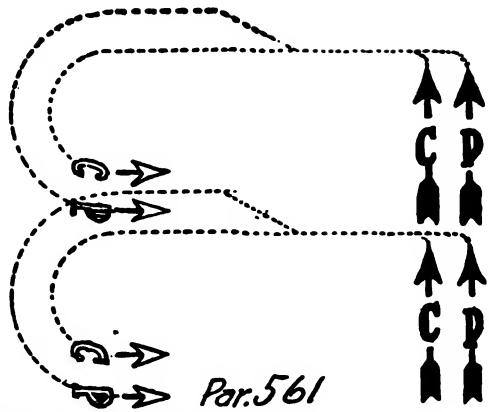
To Fire to the Flank

Par. 561. "Action Right (Left)." Being in double section column, the caisson on either side of the piece.

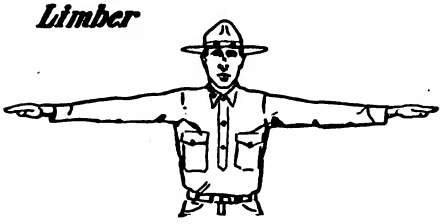
The first sergeant commands "Limbers by the Left (Right) Flank." The caisson corporals repeat the command and execute it, then each caisson corporal causes his limber to incline to the right so that when the "Left About" is executed, forty yards in rear, each limber will be in rear of its piece or caisson.



Par. 561

"Action Right (Left)," From Double Section Column Will Post The Limbers As Shown.

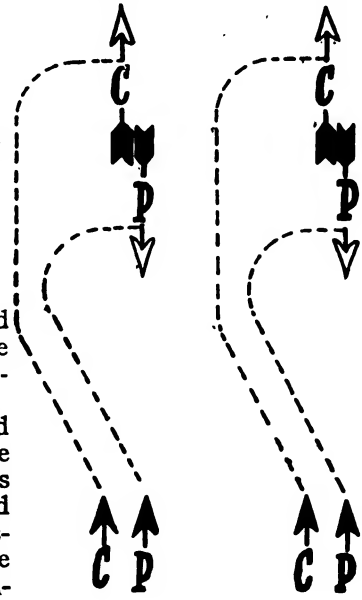
If before "Action Right (Left)" the pieces were on the left (right) of the column, the piece limbers allow the caisson limbers to precede them in the same manner as in "Action Rear" (after the flank movement has been executed, not before), and then take post on the right of the caisson limbers.



To Limber Front and Rear

Par. 562. "Limber Front and Rear." Being in order in battery the limbers posted in rear of their respective sections.

At the signal "Limber Front and Rear," given by the executive at the firing battery, the first sergeant gives the whistle signal "Attention" and the arm signal "Limber." The caisson corporals immediately take charge of their limbers and command "Incline to the Left." The limbers of each section move in the indicated direction (approximately 22½° to the left of their front) guiding on the section to the left.



Par. 562

"Limber Front And Rear," The Limbers Being Posted In Rear.

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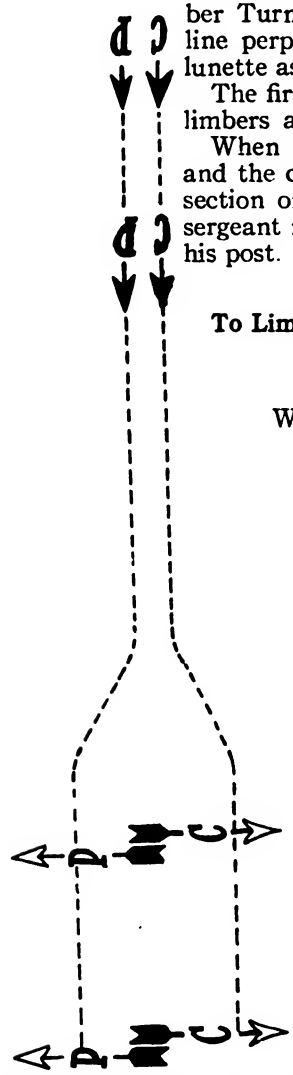
When the lead horses of the piece limber arrive on the prolongation of the line through the lunettes of the pieces the piece limber changes direction to the right and moves along the line of lunettes until the withers of the wheel pair are opposite the lunette of their piece when all drivers execute the limber turn. The caisson limber continues to move to the front until it arrives on the prolongation of the line through the caisson lunettes when it changes direction to the right and limbers in the same manner as the piece limbers.

To obtain the maximum efficiency in the "Limber Turn" the limber must be brought in on a line perpendicular to the trail and as near to the lunette as possible.

The first sergeant supervises the alignment as the limbers are moving in.

When all sections having completed limbering and the chief of the fifth section has assembled his section on the proper flank of the battery the first sergeant reports the battery "In Order" and takes his post.



Par. 562 "Limber Front And Rear; Limbers Approaching From The Flank.

To Limber Front and Rear, the Limbers being Posted on the Flank

When posted on the flank the limbers should approach in double section column; if entering from the right flank caisson limbers should be on the right of the column, if from the left they should be on the left of the column.

Care should be taken that the left section limbers are at the head of the column if the limbers approach from the right flank, and vice versa.

The first sergeant takes post at the head of the column and as the limbers approach the battery he gives the command and signal "Limber," the limbers separate and continue to move forward until opposite their respective sections and in proper place to execute the limber turn. The chiefs of section supervise the limbering of the pieces and the caisson corporals that of the caissons.

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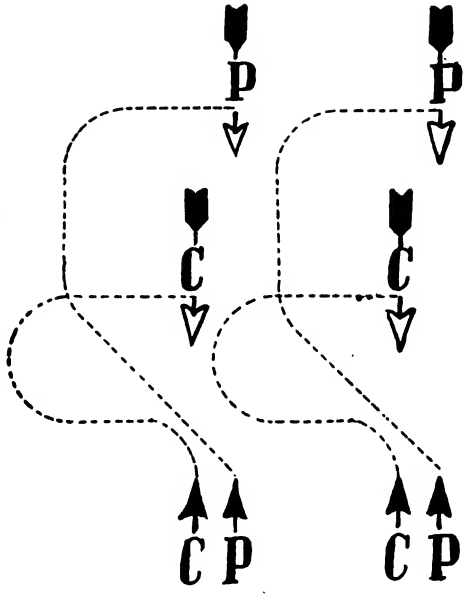
Limber Rear

Par. 565. "Limber Rear." The limbers being posted in the rear.

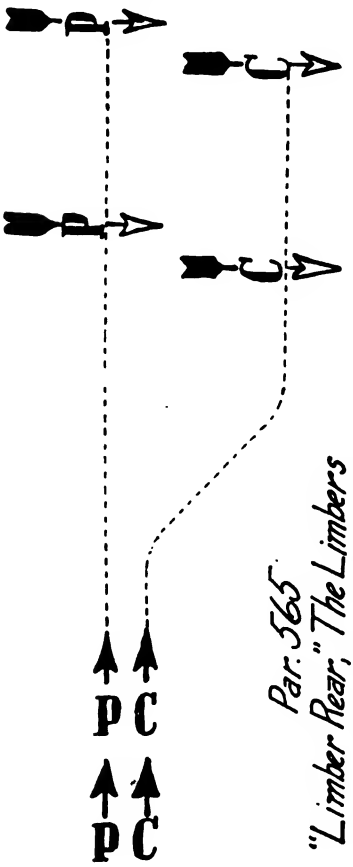
The caissons having been placed by the cannoneers twenty yards in rear of their former position in battery, trails in the same direction as the piece trails; and the limbers being posted in the rear.

The first sergeant repeats the command "Limber Rear" after the caissons have been placed. The caisson corporal commands "By the Left Flank" and after having moved off about fifteen yards in the indicated direction commands "Right About" and inclines slightly to the right in order to move across the caisson trail. The caisson is then limbered as in "Limber Front and Rear."



Par. 565
"Limber Rear," The Limbers Being Posted In Rear.

The Piece Limbers pass to the left of the caissons and then incline to the right, changing direction to the right in order to cross the trail, and limber as in "Limber Front and Rear."



Par. 565
"Limber Rear," The Limbers Approaching From The Flank.

To Limber Rear, the Limbers Being Posted on the Flank

The same commands and rules apply as in "Limber Front and Rear," the limbers being posted on the flank, except that the limbers are formed either in flank column with twenty-yard intervals or the caisson limbers separate very sharply from double section column. The fifth section caissons are not moved to the rear, so the fifth section limbers will come in on the same side as the piece limbers.

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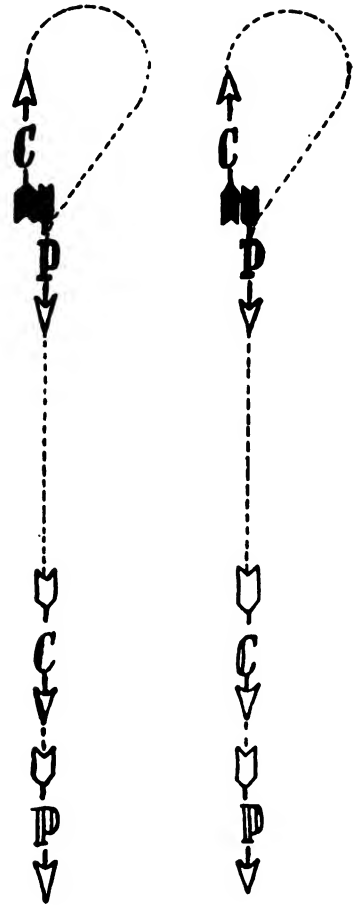

"Pieces (Caissons) Front," From Limber Front And Rear Forms Order In Line.

To Resume the March, after Limber Front and Rear

After having limbered front and rear the teams of each section are facing in opposite directions and it becomes necessary to resume a marching formation.

Par. 563. To March in Line. "Pieces (Caissons) Front."

At the preparatory command, each chief of section commands "Forward." The pieces move straight to the front. Caisson corporals command "Right About" and incline slightly to the right, increasing the gait by one degree so as to follow in section column the pieces of their respective sections. Caissons conform to the gait of the piece after the sections have been formed in section column.

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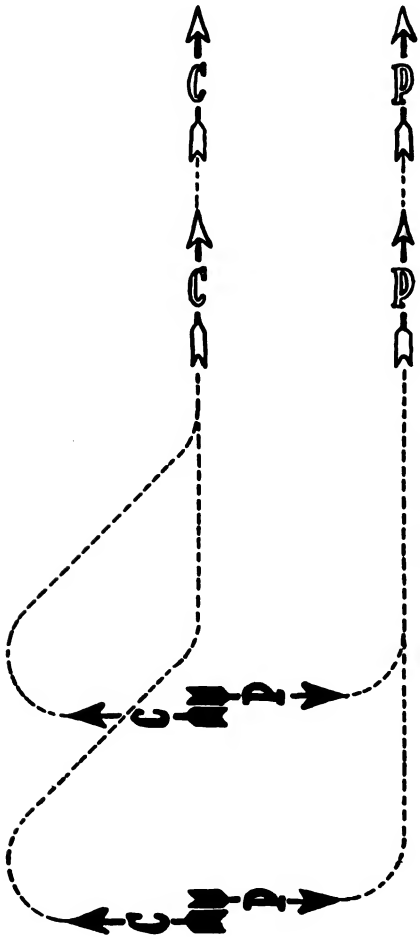
Par. 564. To march in column by the flank.

"1. {Double section. / or / Flank column.} 2. Pieces by the Right (Left) Flank. 3. March."

At the preparatory command chiefs of section command "By the Right (Left) Flank"; the caisson corporals command "By the Left (Right) Flank."

The pieces execute the turn to the indicated flank and move straight to the front.

The caissons execute the turn to the indicated flank and then by two obliques place themselves abreast of their pieces in flank column or double sections as the case may be. Caissons take the gait of the pieces upon arriving abreast of them.



Par. 564
"Flank Column. Pieces By The Left (Right) Flank," From Limber Front And Rear Forms Flank Column To The Right (Left) Of The Firing Front.

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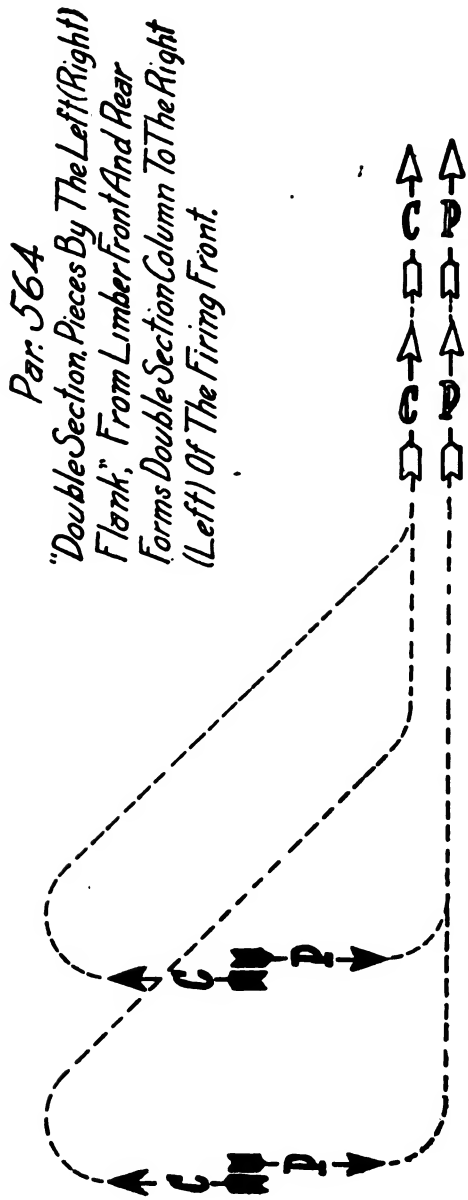

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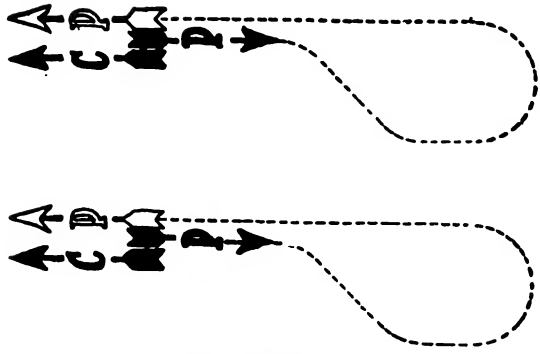

Par. 568

"Form Double Section Line," From Limber Front And Rear Forms Double Section Line To The Front.

Par. 568. To Form Double Section Line, after having limbered front and rear.

"1. Form Double Section Line. 2. March."

At the preparatory command the chiefs of section command "Right Oblique"; the caisson corporals caution "Stand Fast."

Each piece obliques to the right and after having moved ten yards the chiefs of section command "Left About" and place their carriages in double sections on the right of the caisson.

To Resume the March after Limber Rear

After having limbered rear the teams are all facing in the same direction.

To form order in line. "1. Pieces (Caissons) Front. 2. March."

Each chief of section commands "Forward"; each caisson corporal cautions "Stand Fast."

Pieces move straight to the front. After the pieces have cleared the caisson, the caisson corporals command "Left Oblique" and follow their respective pieces in section column.

To march in column to the flank.

"1. Double section, } 2. Pieces by the Right (Left) Flank. 3.
1. Flank column, } March."

At the preparatory command both the chiefs of section and caisson corporals command "By the Right (Left) Flank."

All carriages turn to the indicated flank, pieces moving straight to the front. Caisson corporals, immediately after completing the turn, command "Right (Left) Oblique" and then "Left (Right) Oblique," placing themselves abreast of their respective pieces in double section formation. It is not necessary to oblique to form flank column for each section already has its proper interval after executing the turn.

Caissons take the gait of the pieces after forming double section.

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Harnessing and Unharnessing in the Field

When artillery goes into camp in the field the picket line is stretched between the wheels of carriages. If a single line is to be stretched the battery goes into park formed in line with normal interval (17 yards) between sections. If a front and rear line are to be put up the interval should be 8 yards. The line is stretched in the following manner. One end of the picket line is tied with a clove-hitch to the spoke below the hub of the right wheel of the right

Fig. 1. Attaching end of picket line. Tie used on spoke just below hub is a clove-hitch.

gun or caisson, depending upon whether the front or rear line is being stretched. As little line as possible is used in making the tie on the spoke. The line is then passed over the top of the wheel, around the felloe, over the top again and then under the handrail, across the carriage to the next carriage. The rope is run over the right wheel of the second carriage, under the handrails to the left wheel where it is passed around the felloe as described for the first wheel. A detail of ten cannoneers and a corporal is used to do this work. Six take hold of the rope between the carriages and prepare to heave on it when four men stationed at the left wheel of the second carriage raise the wheel from the ground. The wheel is raised about eight inches and the corporal at the wheel takes up the slack around the

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felloe as the six heave on the rope. When the slack is well out of the rope the wheel is lowered to the ground. The corporal snubs

Fig. 2. Stretching picket line between carriages. Cannoneer marked X is taking up the slack provided by the lifting of the left wheel of the carriage and by pulling on the line, and is holding all the line he gets by means of a round turn on the felloe.

the line on the felloe to prevent the line slacking between the carriages before the next section has been stretched. In a similar manner the succeeding sections are stretched. The left end of the line is secured in the same way as the right end by a clove-hitch on the spoke below the hub.

While the detail of cannoneers has been at work on the picket line the drivers have unhooked and unhitched their pairs. The

Fig. 3

lead pair are tied to the right wheel of the piece, the swing pair to the right wheel of the limber, and the wheel pair to the left wheel of the limber. The drivers then proceed to unharness. The

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wheel driver first unyokes his pair, starting with the near horse, unhooking the side straps from the D ring.

All drivers then uncouple. Next they remove the traces and place them temporarily on some part of the carriage until they have the saddle on the pole.

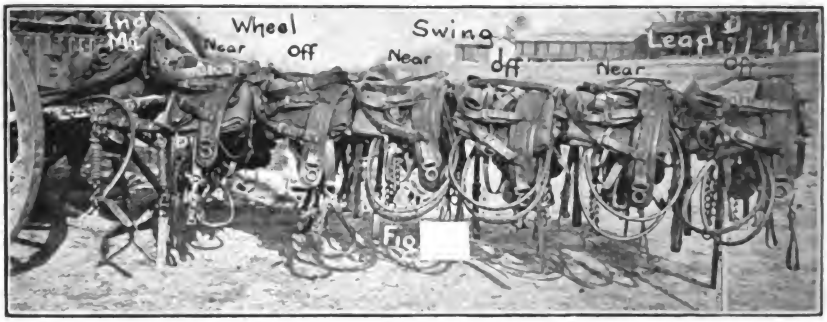

Fig. 4

One of the cannoneers secures the pole prop from under the limber chest and places it in position under the end of the pole so as to support it firmly.

In unsaddling, the driver starts with the near horse. After loosening the cinch and crossing stirrups, cinch, and cinch strap over

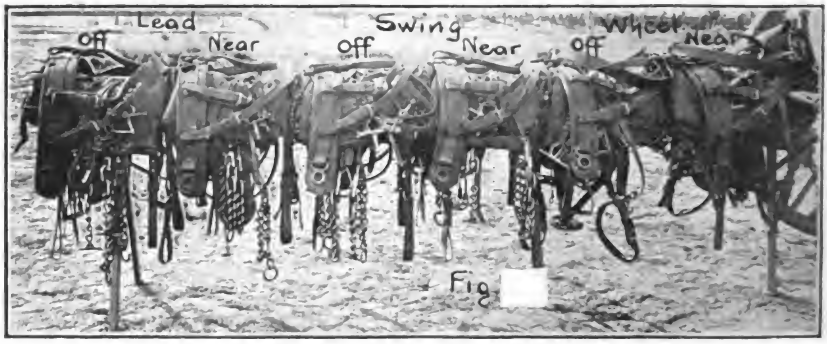

Fig. 5

the saddle he unfastens the crupper and places the backstrap and crupper in the saddle. The collar strap is unhooked last. The saddle and blanket are removed and placed on the pole. Then follows unbridling and last the collar is removed.

The harness is arranged on the pole in the following manner. The saddles are put on the pole from rear to front in the order: near

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wheel, off wheel, near swing, off swing, near lead, off lead. The pommels of all saddles are to the front. The traces are placed on the saddles and over them the blanket with the single edge to the front of the pole and the double-folded edges to the rear. The bridle, with the reins folded over, is placed on the blanket. The collar for inspection is laid over the blanket with the zinc surface (the bearing surface) up. After the inspection the zinc side should be turned down and the collar placed with the front of the collar to the front. With the breast collar the bearing side should be up for inspection and at other times down. All loose ends of the harness should be kept well up off the ground. For protection from the weather the paulin carried on the limber seat is covered over the harness. It should be completely under and over the pole and harness so as to prevent the soiling of the equipment by the splashing of rain or mud from underneath.

By the time the horses are unharnessed the picket line will be stretched and the horses should be tied securely to the line. Each section ties its horses to the part of the line adjacent to its carriage.

In breaking camp the work is done in the reverse order. The horses are taken from the picket line and tied to the carriages to be harnessed. The cannoneers take down the line and secure the sections of it on the proper carriages. The pairs are hooked and hitched and the battery is ready.

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CHAPTER XIII

CLEANING AND CARE OF EQUIPMENT

Cleaning and Care of Leather

ALL leather contains more or less oil. When the amount of oil decreases the leather becomes harder, less pliable, and shows a tendency to crack. It loses its elasticity and breaks more readily under sudden strains.

Exposure to the sun evaporates the oil, and exposure to rain washes it out, both conditions tending in the long run to bring the same result, namely, hardening and stiffening of the leather.

Accumulations of foreign substances are very injurious for they tend to absorb the oil from the leather underneath, leaving it dry and hard; or they retain moisture on the surface, prevent the air from getting to it, and rot the leather. Also many substances, such as perspiration and excretion from the horse, contain chemicals which are very injurious. For these reasons all leather must be kept clean.

The cleaning agent used is "castile soap" and clean water.

All pieces should first be taken apart and as much dust and dirt as possible removed with a damp sponge or cloth. All remaining dirt is then removed by washing with castile soap and water.

In doing this always use as little water as possible. Wring the sponge out nearly dry, rub it on the soap and work it with the hands until a thick, creamy lather is formed. Then scrub the leather thoroughly until all dirt is removed.

Special care should be taken around spots that have been in contact with metal, perspiration, or excreta. If there is an old accumulation of dirt (which there should not be) a soft stick may be used to scrape this off. Never allow any sharp-edged instrument to be used.

After all dirt is removed run the sponge in one direction, all the way along the leather, to remove all remaining loose dirt and extra leather. Never allow the pieces to be rinsed off in a bucket of water.

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Metal parts should be washed thoroughly and dried and if necessary any rust removed with crocus cloth.

Although as little water as possible is used some of the oil in the leather will certainly be washed out, and, to keep the leather in proper condition, it must be replaced. After an ordinary cleaning this is normally done by an application of saddle soap.

Saddle soap is not a cleaning agent—only a dressing for leather. It contains enough oil to replace, if properly applied, all loss through ordinary use. It is used in the same manner as castile soap in the form of a thick creamy lather, rubbed well into the leather, and allowed to dry. The leather should be well rubbed with the hands while drying, to keep it soft and pliable, and to work the oil in.

Always allow it to dry in the shade, preferably for several hours, and never assemble pieces, especially fastening straps into buckles, until thoroughly dry.

Oil is never applied directly to leather unless it has become so hard and dry that saddle soap is not sufficient to soften it. There is only one oil issued for this use. That is "neat's-foot oil." This should be applied only to the flesh side of the leather and very lightly. Several light applications give much better results than a few heavy ones. The oil should be well rubbed in with the hands and should preferably be applied after cleaning the leather with castile soap and water, as the pores of the leather are then more open and the oil penetrates much better. Never oil leather until it becomes greasy, for, besides being wasteful, it makes the leather too spongy.

In emergencies, where neat's-foot oil cannot be procured, any good vegetable oil may be used, preferably olive oil. This is not to be used unless neat's-foot oil or saddle soap cannot be had.

All new leather equipment should be cleaned with castile soap and water as soon as unpacked, as leather very often becomes covered with mold after being packed in boxes for some time.

Ordnance leather as it comes to the battery is very dry and should be thoroughly oiled before being used. New equipment, after being washed thoroughly, should be given, in several light applications, as much oil as it will absorb without becoming greasy. Each application should be allowed to dry thoroughly and should be given frequent rubbings to soften the leather.

With the proper kind of preparation for use there is no excuse for the large amount of broken new leather equipment which is so common.

In packing harness for shipment, especially into harness sacks, the harness should be cleaned and oiled and then dried for at least twenty-four hours before putting into the sacks.

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After removing from the sacks at the destination, cleaning and dressing with saddle soap are sufficient.

When leather is dirty, clean it—not to improve its looks but to preserve it.

When wet allow to dry in a warm (not hot) place, in cold weather; or in the shade in summer. When it is dry, apply saddle soap or oil.

Never hang any piece of equipment over a nail or sharp edge, as cracks always develop where the leather has been folded over sharply.

Ordinary oils and greases rot leather, so all such equipment must be kept away from contact with them.

Never leave any piece of leather where it will chafe against any sharp edge or corner and never leave it exposed to the sun any longer than is necessary.

Care of Cloth Equipment

All cloth equipment should be kept as clean as possible by continual brushing. The fewer times it is necessary to wash it, the longer its life.

Canvas goods, such as paulins, webbing, etc., when it becomes necessary to wash them should be scrubbed with Paco, or H. & H., soap and water.

Make a solution of one cake of either soap in nine cups of hot water. Brush the article to be cleaned thoroughly and spread it on a clean table. Scrub with the above solution and scrubbing brush until a good lather appears. Rinse in clean water and hang in the shade to dry.

Woolen articles may be cleaned in the same manner or with ordinary laundry soap, the first method being always the better. It is preferable to wash these in cool or warm water, as hot water shrinks them. Never wring woolens out, but after washing rinse in clean water and hang immediately up to dry.

Saddle blankets should be kept well brushed and should be frequently unfolded, hung in the sun, and beaten with a whip. When removed from the horse they should be doubled over with the wet side out and put in the shade to dry. If no shade is available, and they must be exposed to the sun, always fold the wet side inward. With these precautions, saddle blankets should not need washing oftener than twice a year.

In washing, immerse the blanket in tepid soapsuds repeatedly until clean, rinse in clean water, and hang in the sun to dry. Do not scrub the blanket.

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CHAPTER XIV

ENTRAINING AND DETRAINING

Arrangement for Transportation.

The arrangement for transportation of troops by rail is a function of the Quartermaster Corps. To enable the quartermaster to estimate for cars he should be informed as to the exact number of men and animals and the amount of material and equipment to be transported by each separate battery and headquarters.

Train Reconnaissance Officer.

An officer from each battery should be detailed one day ahead as Train Reconnaissance Officer and sent to either the railroad station or yard or to the Transportation Officer of the Quartermaster Corps.

Duties of Train Reconnaissance Officer before Arrival of Train.

He should obtain information on the following points:

(a) Loading point.
(b) Loading to be accomplished from ground or platform level.
(c) Location of point near station where preparation for loading may be made.
(d) Approximate time of arrival of train.
(e) Time when loading may begin.
(f) Time when loading must be completed.
(g) All local instructions.

He must be sure of the existence of everything needed for loading, such as ramps for loading horses and matériel, wooden blocks, nails, etc., for securing the wheeled matériel. If these are not on hand, arrangements should be made for their construction. He should make a diagram, if time permits, of the railroad yard, preparation point for loading, platforms and tracks.

Duties of Train Reconnaissance Officer after Arrival of Train.

Upon arrival of the train the Train Reconnaissance Officer makes a note of the number and kind of cars and, if time permits, fills in the diagram made above, showing also the distribution of men, animals,

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and matériel. He is assisted by a noncommissioned officer who marks each car with a number in order from head to rear and opposite each number writes the number of men, or number of horses, or number and kind of carriages to be loaded in the car. An inspection of the cars should be made by an officer of the Quartermaster Corps accompanied by the Train Reconnaissance Officer.

Equipment Necessary for Loading.

Enough hammers, both ordnance and claw, hatchets, and saws should be on hand to furnish the men detailed to secure the vehicles to the cars. The quartermaster should furnish the following matériel: About 2100 linear feet of 2 by 4-inch timber; eighty pounds of 20-penny (4-inch) nails; ten pounds of 7-inch spikes. If field wagons are to be transported, additional lumber and nails should be procured, 250 feet of 2 by 4-inch timber and ten pounds of nails for each three field wagons.

The stock cars must be inspected to see that they are in good condition throughout, examine the cars to see that there are no broken boards, loose boards, rotten flooring, loose fixtures, protruding nails, loose sides, splinters on the inside, and see that floors and stalls are clean.

The cars should be cleaned and floors covered with sand or sawdust, hay and straw should never be allowed in the cars on account of fire.

Assignment of Duties.

The organization commander, after having received the advance report of the Train Reconnaissance Officer, should formulate his plan and communicate it to the other officers of the battery in time for them to plan the work they are to be in charge of.

(a) One officer must supervise the loading of horses.
(b) One officer must supervise the loading of matériel.
(c) One officer must supervise the loading of baggage.
(d) One officer must supervise the loading of men.

Time for Loading.

The time necessary for loading a battery depends upon the loading facilities and the amount that the battery commander has organized his forces for loading. A battery under ordinary conditions should be loaded in one hour and a half.

Time of Arrival of Battery at Station.

So far as practicable all stores, forage, etc., should be at the loading places before the train arrives. Similarly, each battery,

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complete with all its matériel, animals, and personnel, except those men needed as guards over stores, should arrive, so that the horses may be unharnessed and harness and carriages placed convenient to the loading places before its train is spotted.

Classes of Journeys.

Journeys are divided into two classes—long hauls and short hauls over both mountainous and level country. For the former much more elaborate preparations must be made and the matériel secured more firmly to the carriages. For the short hauls a good many of the precautions mentioned later can be omitted, depending, of course, on the kind of journey, whether over mountainous or level country.

Number of Cars.

The following cars are required for the transportation of the matériel of a light battery:

Flat cars	6
Box car for ammunition	1
Box car for stores, harness, etc	1
Box car for forage	1
Baggage car or box car with end doors	1

The number of box cars for ammunition may be increased according to the circumstances.

Size of Cars.

Flat cars vary in length from 34 feet to 44 feet. Cars longer than 42 feet or shorter than 36 feet are very unusual. The length of the average flat car is 40 feet.

Capacity of American Flat Cars.

In loading a battery, complete gun sections should be kept together. When cars at least 34 feet long are obtained a 3-inch battery will be loaded as follows:

(a) Four cars each to contain:
- One 3-inch gun and carriage.
- Two 3-inch gun caissons.
- Three 3-inch gun limbers.

(b) One car to contain:
- One battery wagon.
- One forge limber.
- Two 3-inch gun limbers.
- Two 3-inch gun caissons.

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(c) One car to contain:
One store wagon.
One store limber.
Two 3-inch gun limbers.
Two 3-inch gun caissons.
One battery reel cart.

If cars 44 feet long are obtained, one additional limber or caisson can be loaded on each, thus reducing the number of flat cars needed to five instead of six. If field wagons are carried with a battery, they are transported on flat cars. Additional cars will be required, one for each three wagons.

Kind of Cars.

Box cars are provided for forage, ammunition, harness, and other property according to the necessities. Unless the batteries are to detrain in the theater of operations, ammunition is usually boxed and carried in a special car. Kitchen supplies, officers' baggage, and such of the personal equipment of the men as are not necessary on the journey are carried in a baggage car provided for this purpose. When these are not available, box cars are substituted in their places.

Number of Cars.

The number of box cars required for loading a 3-inch battery is given above in the table showing the total number of cars required for transporting the wheeled matériel, baggage, forage, and equipment. The number of cars depends, of course, on the amount of equipment, forage, etc., prescribed by orders. If no boxed ammunition is to be transported, the number of box cars may be reduced by one. If no stores other than those which are carried on the march are to accompany the battery, the number of box cars may be further reduced. If tourist kitchen cars are not available, the number of baggage or box cars must be increased by one.

Size and Capacity of Cars.

Box cars are usually at least 36 feet in length. The interior cross section is about 8 by 8 feet. The load capacity varies from 40,000 to 100,000 pounds. It is inadvisable, however, to load a car to its capacity, and 40,000 pounds may be assumed as the load and 800 or 2,000 cubic feet as the cubical capacity of the average box car.

The weight limits the amount of ammunition and of grain which can be carried in a single box car. Cubical capacity limits the amount of military stores of other kinds, especially hay.

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Weight and Size of Baggage and Property.

Twelve hundred pounds of 100 rations of oats occupy a space of about 40 cubic feet. A sack of oats averages about 160 pounds. Fourteen hundred pounds, or 100 rations, of baled hay occupy a space of about 120 cubic feet. When access must be had to forage during the journey, 1,200 rations is a suitable load for a forage car. The stock cars furnished which may be used:

1. The palace stock car, length 36 feet to 40 feet, capacity 16 to 20 animals, each animal in a separate stall with a compartment for attendants.

2. The improved stock car, length 36 feet, capacity 20 to 24 animals, with facilities for feeding and watering in the car.

3. The ordinary stock car, length 30 feet to 34 feet, capacity 16 to 20 animals, with no appliances of any kind.

The capacity of both the ordinary and the palace stock cars averages about 18 artillery horses per car. The ordinary stock car will carry about 20 mules.

Animals are carried in stock cars or palace stock cars. If palace stock cars are not available, a box or stock car should be provided for each six privately owned officers' mounts.

Horse Artillery organizations require the same number of cars as corresponding organizations of Light Artillery, with the exception of stock cars for the animals of the batteries. A horse battery on a peace footing requires 9, on a war footing 14 stock cars.

Order of Cars in Train.

The order in which trains are made up are as follows:

1. Flat cars containing guns, carriages, wagons, pontoons, etc.
2. Box cars containing property.
3. Stock cars containing animals.
4. Box cars containing forage.
5. Baggage cars, last one containing travel rations with open end to rear.
6. Passenger coaches and tourist sleeping cars.
7. Standard sleepers for officers.
8. Kitchen cars. In case kitchen cars are used, it would be found advantageous to place them in the central part of the train used by the men.

When battery train must be divided into two sections, the first section contains the forage car, all the stock cars, and one sleeping car, and the second section all the remaining cars. The first section should be under the command of one of the lieutenants and he

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should have with him the stable sergeant, the horseshoer, one of the mechanics, and a number of other men that can be accommodated.

Loading of the Wheeled Matériel

Preparation of Cars.

As soon as the cars have been accepted they are prepared for loading. The officer detailed to load matériel makes arrangements to have the floors of the cars cleared and the brake handles removed if the cars are to be loaded from the end. Ramps should be placed if necessary and everything prepared for the rapid loading of the matériel.

Loading Squads and Their Duties.

The officer in charge of loading matériel should form squads of six or more privates commanded by a noncommissioned officer. Drivers and gun squads are utilized for this purpose. If the number of ramps or loading facilities do not permit all the squads thus formed to work at the same time, some squads prepare the matériel on the ground and bring it close to the car on the loading platform. Other squads load such matériel on the cars while the remaining squads are employed tying with ropes the wheels of the adjoining carriages. If the carriages are not being loaded at the same time as the horses, the two drivers' squads of a section can bring the carriages **in proper sequence** to the loading platform convenient to the cars. One gun squad may run the carriages from the platform to the car being loaded, while the remaining gun squad places the carriages in the proper position on the cars. If the platform is small and its approaches are difficult, the drivers' squads or those detailed to run the carriages up the ramp on to the platform should be made larger by detailing additional men. If the cars are loaded directly from a ramp, slight modifications will have to be made in the number of squads detailed to handle the matériel. The mechanics of the battery, assisted by any cannoneers so detailed, fasten the carriages to the cars.

Where Cars can be Loaded from.

Cars can be loaded from the following positions:

(a) From a platform on the side.
(b) From a ramp on the side.
(c) From a platform on the end.
(d) From a ramp on the end.

In loading the cars if there is any permanent loading platform along the railroad tracks, the vehicles should be run on these plat-

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forms and loaded from them. If there is no permanent platform in the vicinity, it will be necessary to build a temporary ramp. This should always be built at the ends of the cars whenever possible.

Arrangement of Carriages on Cars.

On the first car are loaded:
- Piece of the 1st section.
- Caisson of the 1st section.
- First caisson of the 5th section.
- Limbers (2) of the 1st section.
- Limber of the 5th section.

On the second car are loaded:
- Piece of the 2d section.
- Caisson of the 2d section.
- Second caisson of the 5th section.
- Limbers (2) of the 2d section.
- Limber of the 5th section.

On the third car are loaded:
- Piece of the 3d section.
- Caisson of the 3d section.
- First caisson of the 6th section.
- Limbers (2) of the 3d section.
- Limber of the 6th section.

On the fourth car are loaded:
- Piece of the 4th section.
- Caisson of the 4th section.
- Second caisson of the 6th section.
- Limbers (2) of the 4th section.
- Limber of the 6th section.

On the fifth car are loaded:
- Battery wagon and forge.
- Caissons (2) of the 7th section.
- Limbers (2) of the 7th section.
- Forge limber.

On the sixth car are loaded:
- Store wagon.
- Caissons (2) of the 8th section.
- Limbers (2) of the 8th section.
- Store limber.
- Battery reel cart.

Preparation of Carriages for Loading.

The carriages should be prepared for loading before placing them on the cars. They should be placed **exactly in the order in which**

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they are to be loaded and as close to the cars as possible. In loading the first car they should be placed in order as follows: First caisson, fifth section; caisson, first section; gun; limber, first caisson, fifth section; caisson limber, first section; gun limber. In loading the second car: Second caisson, fifth section; caisson, second section; gun; limber, second caisson, fifth section; caisson limber, second section; gun limber. In loading the third car: First caisson, sixth section; caisson, third section; gun; limber, first caisson, sixth section; caisson limber, third section; gun limber. In loading the fourth car: Second caisson, sixth section; caisson, fourth section; gun; limber, second caisson, sixth section; caisson limber, fourth section; gun limber. In loading the fifth car: First caisson, seventh section; second caisson, seventh section; battery wagon; limber, first caisson, seventh section; limber, second caisson, seventh section; forge limber. In loading the sixth car: First caisson, eighth section, second caisson, eighth section; store wagon; limber, first caisson, eighth section; limber, second caisson, eighth section; store limber; battery reel cart. The above order is varied slightly when the cars are loaded from the side. (See paragraph "Loading.") All tools, lanterns, etc., should be firmly secured to the carriages. The mogul springs should be fastened as follows: A piece of baling wire should be wrapped once across the end of the hooks on the singletrees and the ends twisted two or three times. When short cars are used in loading the last car it may be necessary to take out the pole of the last limber. This should be returned as soon as the limber is in position.

Number of Cars to be Loaded at a Time.

Ordinarily no attempt should be made to load more than one vehicle at a time. When a long permanent platform is available at the side of the cars, two or more cars may be loaded at once, depending upon the number of squads available and the amount of time for loading. Frequently the length of the loading platform will be such that several of the cars must be reached by running the carriages across other cars.

Loading.

If cars are loaded from the end, the carriages are put on in order from front to rear. To load the first car when the carriages are run across other cars, the procedure is as follows: The drivers' squads or cannoneers assigned run the carriages to the edge of the platform at a convenient car in the order prescribed for the preparation of carriages. The limbers are taken up: the ramps with the poles

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first; the pieces with the trails last; the caissons, battery, and store wagons with their trails last. Each of the carriages is placed with its trail or pole pointing squarely across the car on which it is first to be placed. The gun squad designated to run the carriages to the car being loaded, take the carriages as they are placed by the drivers. Each caisson and gun is successively drawn on to the car and its trail turned **away from** the direction in which it is going to be run. The pole of each limber is turned **in the direction** in which it is to be run. Guns and caissons should always be loaded with trails pointing toward the **rear** of the train. The first caisson delivered is placed with the trail pointing toward the middle of the car, the wheels resting about 3 feet from the end of the car. The next caisson is placed in a similar position, tires squarely against those of the first. The gun carriage is placed with its trail in the same direction as those of the caissons (to the rear), the wheels so placed that no part of the gun or carriage touches the caisson. The piece should be about eight or nine inches to the right or left of the center of the car so that the axles of the limbers will be perpendicular to the sides of the car. In long cars the piece can be placed almost in the center of the car. The limbers are put on in the order in which they are delivered, *i.e.*, in the order in which their carriages are placed on the car. The poles point in a direction opposite to that in which the trails do. The pole of the first limber to be loaded is placed under the right trail seat of the gun, the wheels so that **no** part of the limber will touch the gun or carriage. Each of the other limbers is placed tire to tire with the limber next before it. The wheels of the limbers must be in line and also those of the caissons so that side pieces as long as possible may be used. The wheels of the last limber to be loaded on each car are about 3 feet from the end. The other cars are loaded in a similar manner, the store wagon or the battery wagon being placed as prescribed for a gun carriage. The reel cart is loaded as prescribed for a limber, the carriages on the sixth car placed as close together as possible, without allowing the store wagon to touch any of the adjacent vehicles. In loading the last car the pole of the reel cart must be taken off before attempting to place the cart in position. The pole should be put back as soon as the cart is in place. A squad of men is detailed to place the 2 by 4 inch blocks in their proper places. This squad simply puts them in their positions without securing them. As each carriage is loaded the mechanics and cannoneers detailed secure the blocks. They secure one carriage at a time so as to be certain not to omit any of the braces or blocks. When necessary, a squad is detailed to secure the wheels with picket ropes to the stake pockets on the car

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or to each other, the former being preferable when the journey is to be over particularly rough country. In order to secure the adjacent wheels together, picket ropes are wrapped around the felloes where they abut against each other and are strung from carriage to carriage. Any convenient knot is used. In order to secure the wheels to the stake pockets the picket rope is tied to the spokes close to the hub on the side opposite to the stake pocket to which the wheel is to be tied. The rope is then run down through the pocket, up to the next carriage, and is fastened to the spokes on the far side of the hub of this wheel. (See diagram.) The brake wheels are replaced as soon as each car has been loaded. All tools are put away and some of the extra lumber placed on each car for repairing purposes.

When the cars are loaded from the side, the carriages are put on, starting from the ends and working toward the center instead of working from front to rear as above. Take for example loading the first car from the side. The carriages are loaded in the following order: first caisson, fifth section; caisson, first section; gun; gun limber; caisson limber, first section; limber, first caisson, fifth section (see paragraph "Preparation of Carriages for Loading"). The other cars are loaded in a similar manner.

Loading in the Field.

In the field when sufficient lumber cannot be obtained, chocks must be improvised from all available material. Often ramps have to be made of hay bales and any available timber.

Loading Field Wagons.

Before field wagons are loaded their poles must be removed, provided three are loaded on a car. In this case the poles are not put back until the end of the journey but are secured to the wagons. If the wagons are packed before loading, great care must be taken to see that the load is absolutely secure and all equipment fastened. Due to the height of the wagon, extra cross pieces should be placed over the felloes. The wheels of the wagons are placed so that one of the spokes is almost vertical. One cross piece is nailed over the felloes on one side of the spoke and one on the other. These must be secured with 7-inch spikes.

Method of Securing Carriages.

The vehicles are secured with timbers as follows:

(a) Pieces nailed to the floor of the car on both sides of each wheel prevent transverse motion.

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(b) Pieces in front and rear of each wheel prevent longitudinal motion.
(c) Pieces placed on the lower part of the felloes prevent vertical motion.
(d) Blocks are placed on top of the side pieces to raise the cross-pieces high enough to go over the felloes.
(e) Small blocks secure the poles and trails of the caissons and pieces.

Size of Timbers.

The pieces nailed on both sides of the wheels vary in length according to the size of the car but should be full length, if possible. Full length timbers can only be used on very long cars. All cross pieces to prevent longitudinal and vertical motion should be seven feet long. Blocks to raise the cross pieces should be two feet long. All reënforcing pieces should be two feet long. The table below shows the number of pieces of timber, their length and use when a car 34 feet long is used:

No. of pieces 2 by 4 in. timber	Length in feet	Use
4	16	Side pieces for limbers and reel cart—6th car.
20	12	Side pieces for limbers—1st–5th cars.
163	7	Cross pieces all carriages and side pieces for caissons and pieces.
303	2	Reënforcing blocks for all carriages.

All extra 2 by 4 inch timbers should be carried on the cars for repairing purposes. The 20-penny (4-inch) nails should be used for securing the side pieces and should be reënforced every few feet by 7-inch spikes. The cross pieces and blocks for raising them should be secured by 7-inch spikes. The blocks at the poles and trails are secured by 20-penny (4-inch) nails.

Position of Securing Blocks.

The wheels are secured against transverse motion by side pieces, one on each side of each wheel. On top of each side piece is nailed a block opposite the center of the wheel. This block serves to raise the cross pieces which secure the carriages against vertical motion. Cross pieces are nailed over the felloes to these small blocks. Other cross pieces nailed against the ends of the wheels and on top of the side pieces prevent longitudinal motion. The trails of the pieces

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are secured by nailing two blocks on each side, one over the end of the spade and on top of the side pieces and one against the end of the trail in prolongation of the center one of the gun. The trails of the caissons are secured by nailing one block on each side of the trail and one over the end. The poles are secured by nailing two blocks on each side of the pole, one on top of the other and a cross piece over the end of the pole. The brakes on all carriages should be set. In going over rough or mountainous country or on very long journeys, picket ropes should be used in lashing the wheels to the stake pockets on the car. The diagrams which follow show in detail the method of loading and securing a 3-inch battery:

DIAGRAM SHOWING CARRIAGES LASHED TO STAKE POCKETS.

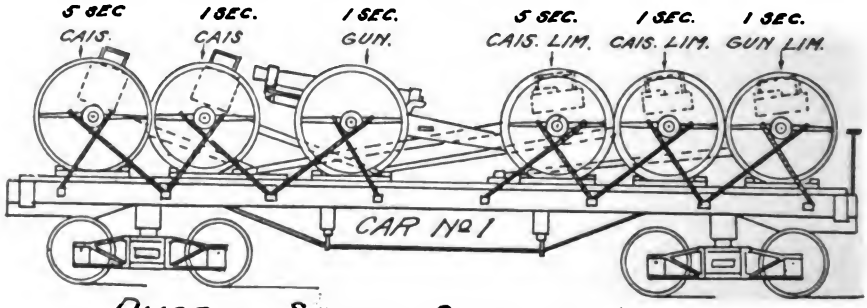
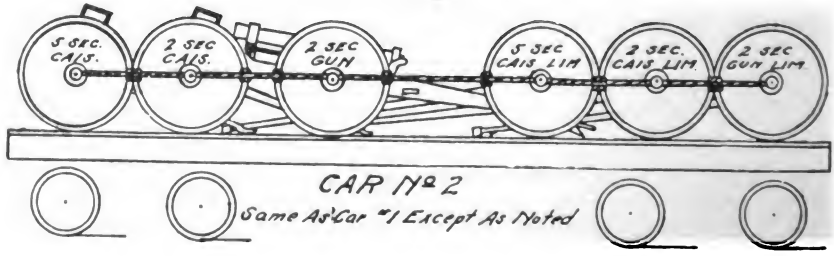
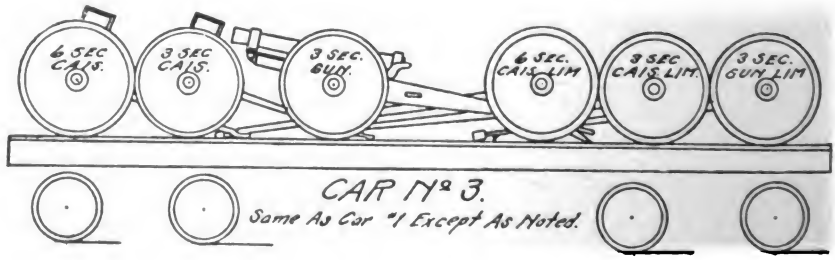


DIAGRAM SHOWING CARRIAGES LASHED TO EACH OTHER





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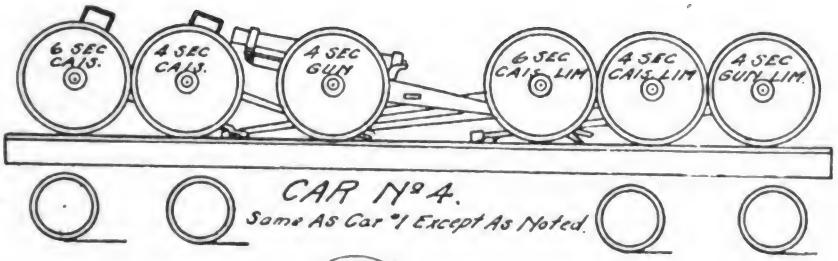
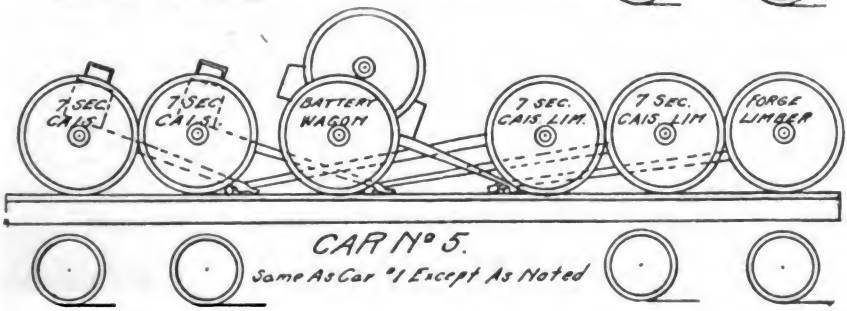
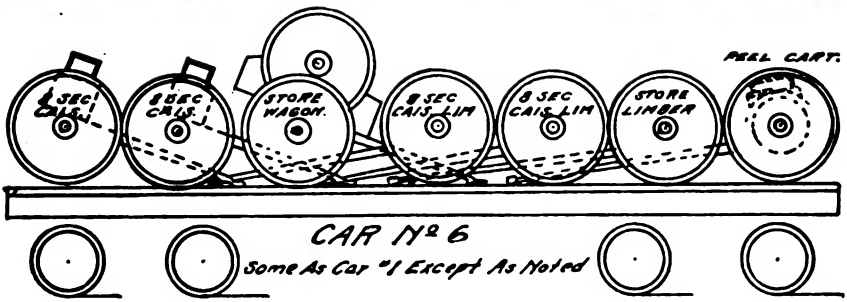


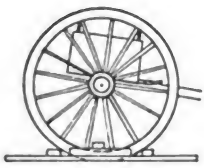
CAR Nº 4.
Same As Car "1 Except As Noted



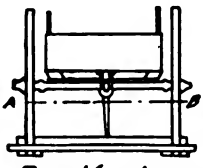
CAR Nº 5.
Same As Car "1 Except As Noted



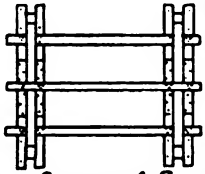
CAR Nº 6
Same As Car "1 Except As Noted



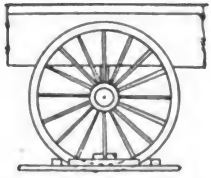
SIDE VIEW - LIMBER
Wheels secured by 2 by 4 inch timbers



REAR VIEW-LIMBER
Wheels secured by 2 by 4 inch timbers.



SECTION A-B
Wheels secured by 2 by 4 inch timbers.



SIDE VIEW-FIELD WAGON
Wheels secured by 2 by 4 inch timbers

SIDE VIEW
TRAIL OF PIECE.
Secured by 2 by 4 inch timbers.

REAR VIEW
TRAIL OF PIECE.
Secured by 2 by 4 inch timbers.

SIDE VIEW
POLE OF CARRIAGE.
Secured by 2 by 4 inch timbers

SIDE VIEW
TRAIL OF CAISSON.
Secured by 2 by 4 inch timbers.

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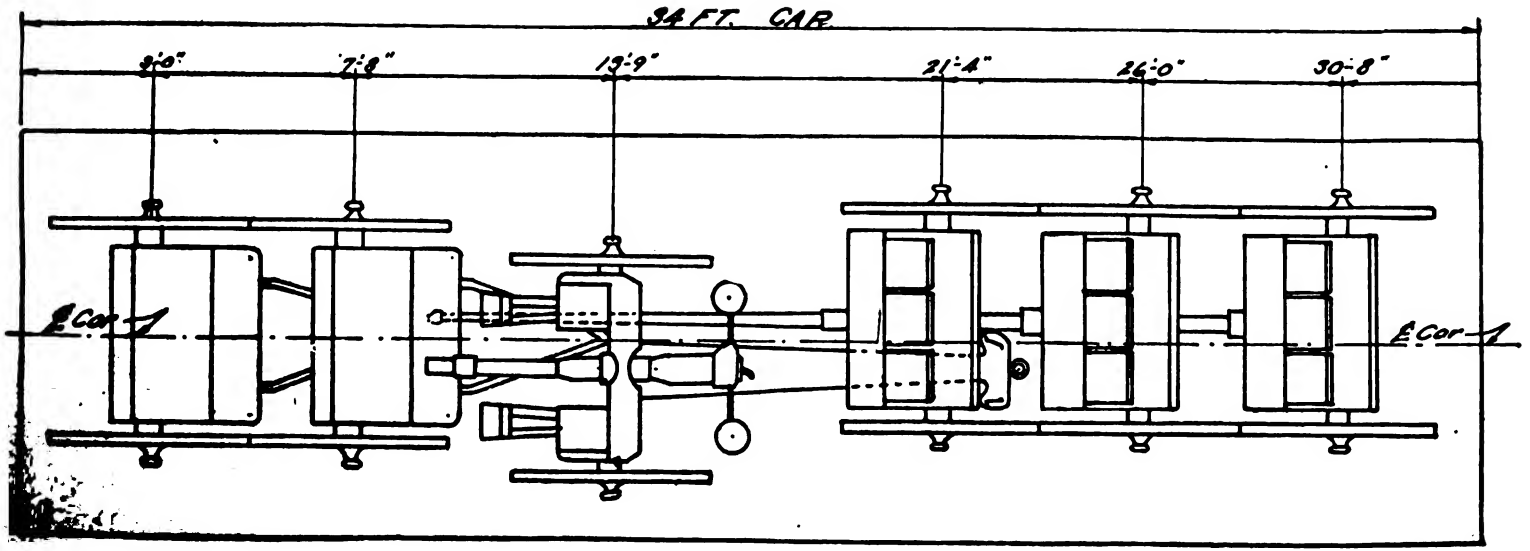
PLAN OF CARS 1-2-3 AND 4



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Inspection by Officer in Charge of Matériel.

After all the matériel has been loaded and secured the officer in charge of loading matériel should make a thorough inspection to see that it has been loaded and secured properly. During the inspection he should pay particular attention to the following points: (1) That all blocks are nailed securely, not simply placed in position. (2) That all the necessary blocks have been placed in their proper positions. (3) That the limber and caisson wheels are tire to tire and their axles perpendicular to the sides of the car. (4) That no part of the gun is touching the adjacent carriages. (5) That all tools, lanterns, paulins, etc., are secure. (6) That carriages do not protrude over the ends of the cars so that they touch any carriages on the next car. (7) That the weight is distributed evenly over the entire car.

Loading of Equipment and Baggage

Situation of Baggage Cars.

The officer in charge of loading the baggage and equipment should see that the box cars are spotted in an accessible place. They should be placed next to a platform from which the baggage can be loaded or they should be in a position where the cars can be loaded directly from the trucks. The latter position is always preferable because the cars can be loaded from both sides at the same time. The only objection to it is that if the baggage arrives before the train does, it has to be stored on the ground.

Amount of Baggage, Forage, and Rations.

The amount of baggage, forage, and rations to be taken depends upon circumstances, and should be **definitely** prescribed in the order directing the movement. Ordinarily rations and forage sufficient for three days after the completion of the journey is ample. More than this is unnecessary and causes delay and congestion in detraining and entraining.

Where Cars can be Loaded from.

Box cars can be loaded from platforms or directly from the trucks. The latter is the most convenient but is much slower than the other. If time permits and a permanent loading platform is available, the baggage, forage, etc., may be brought down before the train arrives and piled on the platform. The Train Reconnaissance Officer should be sure to have the box and baggage cars spotted so that the baggage and forage may be loaded conveniently. If there

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is no loading platform the cars should be placed so that trucks may approach from both sides of the car.

Loading Squads and their Duties.

The officer in charge of loading equipment should form squads of six or more privates commanded by a noncommissioned officer. Gun squads are utilized for this purpose. Usually only one car is loaded at a time but if there are enough squads and the facilities for loading more than one car at a time are good, as many as possible are loaded at the same time. If the baggage has to be loaded from a platform, one squad removes the equipment from the truck and places it on the platform. Another squad works permanently in each car, transferring the property to the cars and arranging it inside. If the cars are loaded directly from a truck, only one squad is needed for loading each car. There should be plenty of men detailed for this work because it is the hardest and much delay is caused by assigning only a few.

Convenient to the ranges if possible, all the other equipment being placed at the other end of the car. One of the cooks should be in charge of the loading of the kitchen supplies.

Packing of Harness for Transportation.

When harness sacks are available the harness of each pair is packed in its sack plainly marked. The harness belonging to a single pair is placed in a harness sack in the following order: Neck yoke; collars, one in each end of the sack, bridles, one inside of each collar; traces looped around and outside the collars; blankets, one on each collar; saddles, one on each blanket. The harness sack is securely tied and is tagged to show: (1) the pair in the team; (2) the carriage; (3) the section. Example: L 1 P (Lead of the first piece). The horse equipment of officers and individually mounted men are placed in sacks or, if sacks are not available, wrapped in saddle blankets, plainly tagged. The horse equipments of officers may be placed in the baggage car or, if a separate car is provided, in the car with their mounts. The horse equipments of the individually mounted men are placed in the car with the harness. If harness sacks are not available, grain sacks or a paulin may be used to wrap all the harness pertaining to each carriage. The paulin is folded and secured as prescribed in paragraph 1761, D. and S. R. F. A. The harness having been secured in bundles, the cannoneers place them convenient to the loading place. In carrying the bundle great care must be taken to hold them clear of the ground. They must not be dragged.

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List of Property.

The officer in charge of loading the baggage, etc., should make out a complete list showing all the items going into each separate car, noting on each list the markings and number of the car.

Journeys Near the Theater of Operations.

For movements of a few hours in the theater of operations when the amount of equipment is limited, the harness and stores may be carried in the flat cars with the carriages.

Contents of Cars.

In loading the box car with forage the hay should be placed at the ends and the grain in the middle so that if necessary the horses can be fed along the route without too much inconvenience. The grain bags and halter tie ropes should be placed conveniently in the center of the car. Half of a box car is usually needed for the transportation of stores and rations not needed on the journey. The heavy property is stored at the bottom. In the other end of this same car the harness is placed. Harness should not be put in piles deeper than two packages. Individual horse equipments and the bundles of blanket rolls may be stored on top of the harness. The harness should be placed in the car according to sections so that there will be no delay or confusion in unloading. The ammunition is placed in a separate box car. The weight determines how much shall be transported in each car. The baggage of the officers, kitchen equipment, rations which will be needed during the journey or immediately upon arrival, and such of the personal equipment of the men as is not necessary on the journey are carried in a baggage car. The veterinary supplies should be placed in a convenient place in the baggage car. The blanket roll of each man is tagged and the rolls of each squad are tied into a bundle. These bundles may be carried in the baggage car. The kitchen supplies should be packed convenient to the ranges if possible, all the other equipment being placed at the other end of the car. One of the cooks should be in charge of the loading of the kitchen supplies.

Arrival at Destination.

Upon arrival at the detraining station complete and early information as to the facilities for unloading and other conditions is essential to the orderly planning and conduct of the detraining. For this purpose each train should be met as it arrives by an officer or officers from preceding organizations. The detraining should ordinarily be so conducted as to release the cars as rapidly as possible

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and thus avoid congestion in the detraining station. Following this principle, the men take all their equipment with them upon leaving the coaches; the stock cars are unloaded first, the flat cars next, and finally the baggage cars and the box cars.

Unloading Kitchen Equipment.

Whenever practicable, arrangements are made at once for unloading the kitchen equipment and necessary rations for the first meal and for transporting them to a suitable place. Such cannoneers as are necessary are detailed to assist the mess sergeant and cooks in this work.

Unloading the Carriages.

The officer in charge of matériel finds out from the organization commander where the carriages are to be parked. As they are unloaded they are run into any suitable formation convenient for hitching in, depending upon the amount of space available. A guard is placed over the park as soon as the first carriage is placed. While the horses are being unloaded, the supply sergeant, the mechanics not assisting at the stock cars, and one gun squad proceed to the flat cars and begin the removal of the chocks preparatory to unloading. As the timbers are removed, they are taken to a suitable place and one man is left in charge until they are finally disposed of. The chocks should be kept for further use by the battery. The gun squads run the carriages off the cars on permanent platforms or on ramps. In moving a carriage down a ramp they should not be limbered until on the ground. If the ramp is steep and the carriages heavily loaded, picket ropes are attached to the rear pintles and men assist the squads by letting the carriages down the ramps slowly. As soon as the carriages have been placed the wires which secure the mogul springs are cut. The trails of the caissons must point down the ramp in unloading, otherwise they will topple over. Carriages should be taken down the ramps singly.

Unloading the Harness, Baggage, etc.

Usually a part of the men may be usefully employed in unloading the baggage and box cars simultaneously with the unloading of the carriages. In unloading the harness it should be arranged **by sections** so as to give ample room for harnessing. The harness sacks, under no circumstances, should be thrown out of the car. The officer in charge of baggage, etc., should supervise the unloading. It is usually more convenient to unload directly into the trucks, consequently the cars should be placed to permit this. Ordinarily

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the battery should harness, hitch in, and clear the vicinity as soon as the horses, carriages, and harness have been unloaded. When the box cars have not been completely unloaded all cannoneers not needed to hold horses during the harnessing may be left at work unloading.

Preparation for Loading Horses.

So far as practicable all forage and animals should be at the loading place before the train arrives. The animals should arrive in time so that the horses may be unharnessed and the harness placed convenient to the loading places. As soon as the battery has been unhitched the teams should be taken to the vicinity of the place where they are to be loaded and there unhitched, each two pair should be held by one cannoneer detailed by the chief of section, and the remaining cannoneers assist the drivers in unharnessing and securing the harness.

If stables or permanent picket lines are available near loading place the horses should be secured there and left under charge of two drivers detailed as guards, otherwise horses of each section should be formed in a circle, the halter tie rope of each horse being tied securely to the halter of the horse next to him. Each chief of section details a driver to remain with him, in which case the horses are given a feed of hay which should have been withheld from them for some hours before and should be watered about one hour before loading.

If the horses will probably be unloaded during the journey, each chief of section collects the feed bags belonging to his section and turns them over to the stable sergeant, who makes a memorandum thereof. The grain bags are retained by the men, who pack them with their saddles. The stable sergeant sees that the feed bags, necessary grain measures, a few bandages and disinfectants, and stable tools are placed in the center of the forage car, so as to be readily accessible.

Procure loading pens and chutes if possible. If none available, get railroad platforms or ramps. Make a ramp well supported with strong sides and provide it with cleats to prevent slipping; lanyards should be attached to each side of the floor near the middle and made fast to truss rods in the middle of the car, to prevent the ramp from sliding off the car near the doorsill. Boards and brush may be used to make a bridge. As a last resort use a bridge of earth to reach as near as possible to the side of the car and bridge the gap with the car door.

If loading with improvised facilities, always try to get the car in a shallow cut.

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For each car being loaded four selected noncommissioned officers, a mechanic, and a gun squad should be detailed. Two of the noncommissioned officers are detailed to work inside the car. The remaining noncommissioned officers are detailed to work at the door of the car. Two of the members of the gun squad are detailed to collect the halter tie ropes and see that they are turned over to the stable sergeant at the forage car. The remaining cannoneers assist the noncommissioned officers at the doors. When chutes are available all these men except the noncommissioned officers should remain outside the runways until they are needed. When pens and chutes are available the horses are penned by carload lots. A noncommissioned officer and a driver squad are assigned to work in each loading pen. The horses should not be loaded until the loading of all carriages and stores has been completed.

When the journey is to exceed twenty-four hours suitable arrangements should be made with the railroad authorities for the stop for feeding, rest, and exercise. It is desirable that the place for unloading should be selected several hours beforehand, so that proper notice may be given to the station agent and other railroad officials. In order to avoid reloading the animals at night a station should be selected that will be reached about noon.

The necessary requirements for a suitable feeding station are water and a platform, or preferably, a chute for taking the animals out of the cars.

Ample stock pens, dry footing facilities for renewing the bedding in the cars, etc., are also desirable.

In the United States the state laws for shipping stock should be consulted and complied with.

Loading

The remaining drivers bring the horses from the loading pens and place a new carload lot in the loading pen as soon as the preceding lot has been loaded. As the horses arrive the drivers in the loading pen remove the halter tie ropes and pass them to the cannoneers detailed to collect them. The gate to the runway is kept close until the gangplank is in place, the side gates closed against the gangway, and the noncommissioned officers in place. Everything being in order, the gate is opened and one of the drivers leads a docile horse up the runway. The remaining drivers cause the other horses to follow as closely as possible. This is accomplished without shouting or otherwise exciting the animals. Horses that hold back are slapped or gently struck across the rump with a tie rope. The noncommissioned officers inside the car place themselves near the door and keep

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the horses quiet by speaking to them. When the first horse arrives, one of the noncommissioned officers takes him from the driver and leads him to one end of the car. After this the noncommissioned officers confine themselves to keeping the horses quiet and preventing them from leaving the car. Trained horses are thus allowed to pack themselves in the car. It is desirable that as many horses as practicable be placed in each car not provided with separate stalls.

With horses not trained in loading each noncommissioned officer may be assisted in the car by two men whose duty it is to hold the last horse received, in place across the car. In leading horses be careful to face the front and do not turn around and look at the horse.

The car having been filled, the noncommissioned officers inside the car first put up the breast bar and then leave the car. The gangplank is swung back, the side gates slipped back, and the car door closed. The mechanic fastens the door securely.

When loading pens are not available and the horses must be loaded from a platform similar methods are used except that all the horses are led by drivers into the car. The halter tie ropes are taken off after entering the car and turned over to the cannoneers collecting them as the drivers pass out. In leaving the car the drivers must be careful to avoid interfering with horses just entering.

If shy of the ramp a little hay thrown on the ramp will make them less shy. Do the loading quietly and have the animals follow one another promptly. Before loading the car see that the door on the far side is closed and fastened.

In some cases it may be necessary to blindfold an animal before he can be led into the car. An obstinate animal can sometimes be made to enter by holding his head up, twisting his tail, and pushing him into the car by main force. Another method which can be used is to drop a loop over the horse's croup, pass the end of the rope through the halter to the nose piece, and pull on the rope. This will make him move forward a step or two. If he does not continue to move up the ramp, get enough men on the ramp to pull him in. Another method which can be used, is to tie a blanket over his head or otherwise blindfold the animal, turn him around several times, and lead him up the ramp.

The first animal is led to one end of the car, the second to the other end, leaving the center of the car for the last animals loaded. The animals are arranged so that the alternate ones face in the same direction. Each one led in must be held until the next one is in place.

Load quietly and avoid exciting the animals by too much haste or too much delay.

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The man in charge should be equipped with a saw and hatchet to cut an animal loose if one gets its hoof fastened between the sides of the car.

Except in hot weather the animals should be packed snugly together. If an animal falls down he cannot get up without assistance. The man in charge should crawl alongside the car and take the animal by the halter. With this assistance he will probably get up.

Detraining and Feeding

The train conductor should be requested to notify the train commander immediately before any halt of ten minutes or longer is to occur. During that time the stock cars are to be inspected by an officer, the stable sergeant, and mechanics, and any necessary repairs are to be made at this time.

Before reaching the feeding station the senior noncommissioned officer in each car details a cannoneer to remain in the car as a guard, causes the drivers to get out their grooming kits, and cautions the men that their remaining equipment, except pistols, is to be left in the car.

Upon reaching the feeding station, the men, except the mess sergeant, the cooks, and guards, are notified to leave the cars and fall in at a designated place. Rolls having been called, the drivers are formed separately from the cannoneers.

Two gun squads are detailed to assist the stable sergeant in preparing the forage. These men are at once marched to the forage car. The stable sergeant, upon reaching the forage car, gives the halter tie ropes to one of the gunners who, assisted by a cannoneer, takes them to the stock cars and distributes them as they are needed. These men are responsible for collecting the tie ropes and turning them over to the stable sergeant when the horses are reloaded.

The stable sergeant causes the remaining men of his detail to put one feed of oats in each feed bag and to distribute one feed of hay at the feeding places.

The feed bags are not taken to the feeding places until the animals have been watered, when all the cannoneers assist in this distribution. No attempt is made to give the horses their own feed bags.

As soon as the stock cars have been unloaded, the mechanics begin the repairs. An officer should be detailed to inspect the cars and have the floors resanded. Before any car is unloaded, sufficient drivers to provide one for each two horses are sent to join the detail

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of four selected noncommissioned officers, a gun squad, and one mechanic detailed to each car to be unloaded. The drivers each secure two halter tie ropes. An officer should be in charge of this unloading.

Two of the noncommissioned officers of the above detail are assigned to work inside the car, the others working outside at the door. The cannoneers assist the latter noncommissioned officers and also assist the drivers in catching up the horses. The mechanic removes the fastenings and assists in opening the door.

The principal difficulty in unloading is in preventing the horses from leaving the car before the gangway, gates, or side rails, etc., are in place and in avoiding overcrowding in the doorway.

As soon as the car is in place the door is opened enough to permit the noncommissioned officers who work inside to enter. These men at once enter, leaving the breast bar in place, and quiet the horses nearest the door by speaking to and caressing them. Everything being in readiness, the door is completely opened and the gangway, gates, etc., put in position as quickly as possible.

If a loading pen is available the drivers and cannoneers assigned to the car go into the pen to catch the horses up after they enter it. If no pen is available the drivers and cannoneers line themselves up on either side of the door, each one taking an animal in turn as he leaves the doorway. All men being in their places the noncommissioned officers inside the car remove the breast bar, and every endeavor is made to make the horses leave the car quietly and in single file.

The cannoneers assist the drivers in catching up the horses. As soon as all the animals of the first lot have been caught up the pairs are formed in column and the drivers lead the horses around at a slow walk. A noncommissioned officer should be designated to lead the column of this first lot. As each succeeding car is unloaded and the horses caught up, the drivers join the rear of the column.

If ample feeding lots are available a separate lot should be assigned each separate car. In any case no attempt is made to separate the horses by sections, but effort is made to keep together the horses that have been in the same car and to reload them together. Drivers remain with the pairs which they catch up and do not attempt to find their own horses unless the latter are with the same carload to which the driver is assigned. In this case a driver may be allowed to take his own horses after they are tied up for grooming and feeding.

The object of walking the horses and of the subsequent grooming is to remove the stiffness and swelling of the legs induced by the long

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standing in the cars. For this reason the exercise of the horses should be continued for ten or fifteen minutes after the unloading of the last car has been completed.

Hay having been distributed and the exercising completed, the horses are properly secured and then groomed while they are eating hay. During the grooming particular attention is paid to cleaning and hand rubbing the legs thoroughly. All kicks, cuts, and abrasions are reported to the stable sergeant, who visits all the horses at this time.

During the grooming the cannoneers proceed to the stock cars and renew the sanding if material is available. Tools for this purpose may frequently be had from the railroad or stockyard authorities or they may be taken from the carriages. Sometimes it may be necessary to detail a number of cannoneers to draw water for the animals.

The grooming is continued until the animals must be watered, which should be in time to allow them to eat their grain before it is necessary to begin reloading.

At the proper time the officer in charge of renewing the sand causes the cannoneers to take the filled feed bags and to distribute them. He then details a gun squad to collect the feed bags and turn them over to the stable sergeant at the forage car after they have been removed from the horses.

At least two hours should be allowed for unloading, feeding, and reloading.

In all loading and unloading particular care must be exercised to avoid any shouting or excitement on the part of the men; these are the principal causes of excitement on the part of the horses, which, in turn, is the source of most difficulties in handling the animals.

The horses after being unloaded are arranged by sections and are secured at once, care being taken that they are not tied to a flimsy or movable object. The feed bags are not filled but a feed of hay is fed at once. Two or more cannoneers are set to work to sort the feed bags out by sections and later, when the horses are being harnessed, to turn them over to the chief of sections.

While the foregoing methods of loading and unloading outline the principles which should be followed, the details of the plan adopted must be varied to conform to the conditions of each particular case. The first essential is a definite plan conformable to existing conditions, and its methodical execution without excitement or undue haste.

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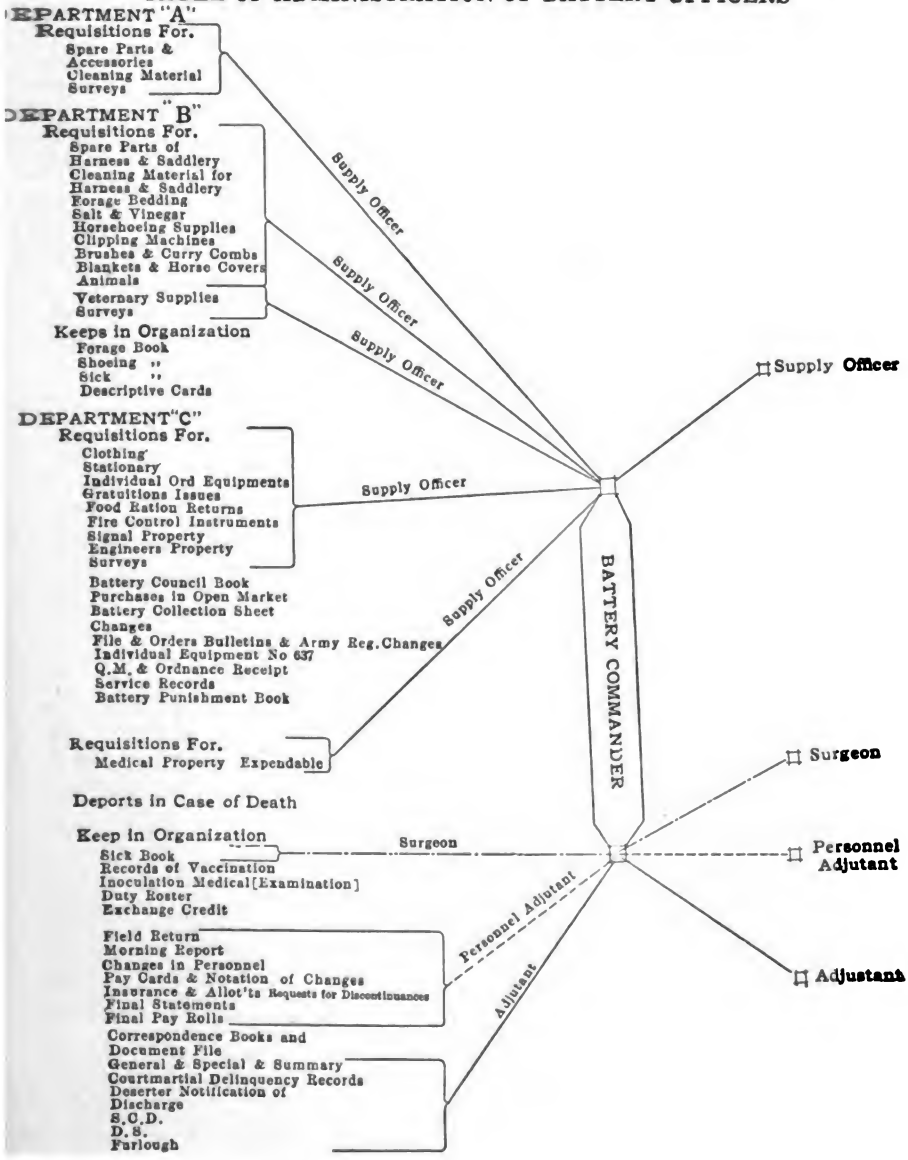
TABLE OF ADMINISTRATION OF BATTERY OFFICERS



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APPENDIX A

ADMINISTRATION

First Week (3 hours).

1. **Conference.**

Army Regulations.

Nature and scope of Army Regulations.
By whom kept.
Changes, issue, and necessity of keeping posted up to date.
Method of using for reference.
How they may be obtained.
Read and explain Pars. 265–302 A. R.

Assignment. Pars. 265–302 A. R.

2. **Conference.**

Battery Paper Work in General.

Necessity of reading carefully instructions relative to the preparation of any form or paper.
Care that sufficient number of copies is made, no details neglected, careful checking to detect typographical errors.
How blank forms may be obtained, which ones should be kept on hand.
Necessity of keeping all paper work, reports, etc., up to date.
List of all routine reports and returns should be kept posted showing dates when they are due.

Form of Official Letter.

Heading. Subject. Number.
Body—spacing, numbering of paragraphs.
Signature—rank and regiment or arm (when unnecessary).
Suitable wording for military correspondence.
Folding.

Indorsements.

Military Channels, Number of Copies.

Making of notations of receipt on back of last fold.

All candidates required to submit a model letter with two indorsements, which will be corrected and returned.

NOTE.—Use blackboard in all paper work. Draw on the board the form or report under discussion, make model entries, erase the entries, and call on the candidates to do likewise after having given them sufficient data.

Assignment. Pars. 775–790 A. R.

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3. **Conference. Battery Paper Work.**

Correspondence Book and Document File.

NOTE.—Candidates should be carefully instructed in what should be kept as a record in the Document File and what should be merely noted in the Correspondence Book.

Surveys.

Battery Returns.

Monthly return.
Field return.
Casualty return.

Furlough Blank and Furloughs. Par. 106–113 A. R.

Procedure, signature of Commanding Officer.
Commutation of rations.

Issue of Clothing, Individual Clothing Record, Requisitions.

Assignment. Pars. 106–113, 811–814, 818 A. R.

Second Week (3 hours).

1. **Conference. Battery Paper Work.**

Battery Fund. Pars. 316–318, 322–324, 327–329, 1220 A. R.

Sources of income.
Collection sheet.
Authorized expenditures.
  Ration savings.
  Other funds.
Battery council and council book.
  Functions of council and of whom composed.
  Methods of keeping council book.
Vouchers (expenditures and receipts).
  Examples.
  Method of filing.
  When a certificate may be substituted.
  Inspection by council and battalion commander.
Pay and Muster Roll. **Par. 807, 1329 A. R.**

Morning Report.

Detailed explanation.
Appropriate entries and abbreviations under "Remarks."
Method of checking.
Method of handling additions and subtractions of rations.

Ration Return.

Example and method of computing.
Usual periods for which returns are made.

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Forage Return.

Sick Report, Duty and Guard Rosters.

Examples.

Method of keeping Duty and Guard Roster so that men longest off will be detailed first.

Assignment. Par. 316–318, 322–324, 327–329, 807, 1220, 1329 A. R.

2. **Conference. Battery Paper Work.**

Discharges and Final Statements. Pars. 139–158, 140–142, 152, 155, 162, 341, 345, 648, 1362–1369 A. R.

Kept in personal possession of battery commander.

General Battery Administration.

Duties of

Battery Commander.
Lieutenants.
First sergeant.
Mess sergeant.
Stable sergeant.
N. C. O. in charge of quarters.
Battery Clerk.

Files of all orders and memoranda with index.

Division of battery into departments A, B, and C.

General Review of Work Covered.

Assignment. Pars. 139–158 140–142, 152, 155, 162, 341, 145, 648, 1362–1369 A. R.

3. **Conference. Manual of Courts-martial. Pars. 2–14, 94–107.**

Read Par. 1835 A. R.

Military law, its sources.

Military tribunals.

Classification of Courts-martial.

Of whom composed.

By whom appointed.

The Judge Advocate.

Brief explanation of the procedure and workings of a general courts-martial, special courts-martial and summary court.

Assignment. Pars. 2–14, 94–107 Manual of Courts-martial.

Third Week (4 hours).

1. **Conference. Disciplinary Powers of a Commanding Officer.**

Read and explain Article of War 104.

Right of man to demand trial.

The Delinquency Book.

Proper court for offenses.

Preparation of charges.

NOTE.—Secure charge sheets and have candidates make out charges laying emphasis on charging under proper Article of War, number of copies and disposition and the additional reports required, such as witnesses and evidence.

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2. **Conference. Field Service Regulations.**

Orders. Art. III F. S. R.

Classification.
Letters of instruction.
Field orders.
General orders.
Special orders.
Orders.
Verbal orders.

Measures necessary before promulgating an order.

The Five-paragraph Order.

Discussion and explanation.
All candidates should be required to memorize sequence of paragraphs.
Read and explain examples in Appendix F. S. R. and have candidates prepare a simple field order.

NOTE.—Lay particular emphasis on the following of the sequence in the five-paragraph order whether the order is written or verbal.

Assignment. Art. III F. S. R.

3. **Conference. Field Service Regulations.**
Marches and Convoys. Art. IV, F. S. R.
Assignment. Art. IV, F. S. R.

4. **Test.**

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APPENDIX B

SCHEDULES

NOTE.—The schedules in the pages that follow were in use at the Field Artillery Central Officers' Training School at Camp Zachary Taylor, Kentucky. They were long in the making and were perhaps more helpful for instruction purposes than anything else which experience taught the officers of the school; for the benefit of other instructors, they have been included in this book.

Observation Area Training Schedule

1. The Training of the Observation Batteries will be governed by a basic and an advanced schedule, each covering one week's work.

2. Each candidate must qualify in the first week's work before he goes to the advanced work. He may continue with the basic schedule for four weeks. If he fails to qualify in that time he will be sent before the Elimination Board. When he qualifies in the first week's schedule he will be placed in the advanced platoon of the Battery, there to be given the advanced work as covered by the advanced schedule.

3. In making up the list of candidates to be sent to Training Batteries, only those in the Advanced Platoon will be taken. When the candidate shows that he is proficient in the first week's work, disregarding the length of time he has been in the Battery, he may be placed in the Advanced Platoon.

4. The basic schedule includes instruction in the fundamentals of Dismounted Drill, Military Courtesy, Guard Duty, and Mathematics. The advanced schedule gives greater opportunity for the candidate to exercise command and to develop himself as an instructor of other candidates in the Battery.

5. The instruction in Mathematics continues until the candidate has been declared qualified by the Instructor in Mathematics. The period devoted to Mathematics may then be devoted to intensified training in the parts of instruction most needed. No candidate will be placed in the Advanced Platoon until he is declared proficient in Mathematics.

First Day

6: 45 to 7: 45 A.M.—Inspection. (F. A. D. R., vol. 1, par. 57 to 74, 97.) Fall In; Count Off; Position of Attention; Rest; Explanation of Demerit System.

7: 45 to 8: 45 A.M.—Guard Duty. Purpose and significance of Guard Duty.

8: 45 to 9: 45 A.M.—Drill. (F. A. D. R., vol. 1, par. 78 to 84, 91.) Saluting; Forward March; Halt.

9: 45 to 10: 45 A.M.—Mathematics.

10: 45 to 11: 15 A.M.—Physical Drill.

12: 30 to 1: 30 P.M.—Mathematics.

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1:30 to 2:30 P.M.—Drill. (F. A. D. R., vol. 1, par. 76, 77.) Facings. Review first hour.

2:30 to 3:15 P.M.—Lectures (F. A. D. R., vol. 1, par. 110, 111, 162). Squads Right (Left). Right (Left) Turn. Column Right (Left).

3:15 to 3:45 P.M.—Athletics. Games in which everyone takes part. To be supervised by the Battalion Commanders.

3:45 to 4:30 P.M.—Drill. Squad movements by numbers. Review day's instruction. Toward close of period, squad movements without numbers.

7:00 to 9:00 P.M.—Evening Study. Lecture. Personal Hygiene. Study Assignment. F. A. D. R. covering work done first day.

Second Day

6:45 to 7:45 A.M.—Inspection. (F. A. D. R., vol. 1, par. 152, 153, 98.) Open Ranks. Right (Left) Dress. Review first day.

7:45 to 8:45 A.M.—Guard Duty. General Orders—detailed explanation of each. Observe Formal Guard Mount at 4:45 P.M.

8:45 to 9:45 A.M.—Drill. Review 1st and 2d periods first day.

9:45 to 10:45 A.M.—Mathematics.

10:45 to 11:15 A.M.—Physical Drill.

12:30 P.M. to 1:30 P.M.—Mathematics.

1:30 to 2:30 P.M.—Drill (F. A. D. R., vol. 1, par. 92, 94, 57–66). Flank marching, change of step, courtesies, combination of facing and hand salute, squad counting, what Distance and Intervals are in different formations.

2:30 to 3:15 P.M.—Lecture. Articles of War, vol. II, Chap. IX. Section A of G. O. No. 32, Camp Taylor. Army Regulations.

3:15 to 3:45 P.M.—Athletics. Games in which everyone takes part. To be supervised by the Battalion Commanders.

3:45 to 4:30 P.M.—Drill. Squad movements by numbers. Review day's instruction. Toward close of period, squad movements without numbers.

7:00 to 9:00 P.M.—Evening Study. Lecture. Personal Hygiene. Study Assignment. F. A. D. R. covering work done first day.

Third Day

6:45 to 7:45 A.M.—Inspection (F. A. D. R., vol. 1, par. 149, 150; vol. II, par. 733, 734, 735). Explanation of post of Officers; N. C. O.'s Mechanism of Inspection.

7:45 to 8:45 A.M.—Guard Duty. Review General Orders—Day and Night Guard Duty—Observe Formal Guard Mount 4:45 P.M. Assignment F. A. D. R., 104–138.

8:45 to 9:45 A.M.—Drill. 1st half period test on first and second day's work. Review School of the Soldier.

9:45 to 10:45 A.M.—Mathematics.

10:45 to 11:15 A.M.—Physical Drill.

12:30 P.M. to 1:30 P.M.—Mathematics.

1:30 to 2:30 P.M.—Drill. Review School of Squad.

2:30 to 3:15 P.M.—Lectures. Leadership. Power of Command.

3:15 to 3:45 P.M.—Athletics. Games in which everyone takes part. To be supervised by the Battalion Commanders.

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3: 45 to 4: 30 P.M.—Drill. Squad movements by numbers. Review day's instruction. Toward close of period, squad movements without numbers.
7: 00 to 9: 00 P.M.—Evening Study. Lecture. Personal Hygiene. Study Assignment. F. A. D. R. covering work done first day.

Fourth Day

6: 45 to 7: 45 A.M.—Inspection. Two Batteries of Battalion by Battalion C. O.
7: 45 to 8: 45 A.M.—Guard Duty. Corporal of the Guard. Observe Formal Guard Mount at 4: 45 P.M. Assignment F. A. D. R., 754–767. N. C. O. Manual 50–57.
8: 45 to 9: 45 A.M.—Drill. School of the Soldier—Military Courtesy.
9: 45 to 10: 45 A.M.—Mathematics.
10: 45 to 11: 15 A.M.—Physical Drill.
12: 30 to 1: 30 P.M.—Mathematics.
1: 30 to 2: 30 P.M.—Drill. School of the Squad. Eyes Right. Take Interval. Take Distance Oblique March (F. A. D. R., vol. I, par. 100 to 110, 75).
2: 30 to 3: 15 P.M.—Lectures. Customs of Service. Honor System.
3: 15 to 3: 45 P.M.—Athletics. Games in which everyone takes part. To be supervised by the Battalion Commanders.
3: 45 to 4: 30 P.M.—Drill. Squad movements by numbers. Review day's instruction. Toward close of period, squad movements without numbers.
7: 00 to 9: 00 P.M.—Evening Study. Lecture. Personal Hygiene. Study Assignment. F. A. D. R. covering work done first day.

Fifth Day

6: 45 to 7: 45 A.M.—Inspection. Two Batteries by Battalion Commander.
7: 45 to 8: 45 A.M.—Guard Duty; Guard Manual—Observe Formal Guard.
8: 45 to 9: 45 A.M.—Drill. School of the Squad. Platoon Drill. Marching in Line.
9: 45 to 10: 45 A.M.—Mathematics.
10: 45 to 11: 15 A.M.—Physical Drill.
12: 30 to 1: 30 P.M.—Mathematics.
1: 30 to 2: 30 P.M.—Drill. School of the Squad. Courtesies. Facings.
2: 30 to 3: 15 P.M.—Lectures. Voice in Giving Commands. Duties of Officers and N. C. O.'s.
3: 15 to 3: 45 P.M.—Athletics. Games in which everyone takes part. To be supervised by the Battalion Commanders.
3: 45 to 4: 30 P.M.—Drill. Squad movements by numbers. Review day's instruction. Toward close of period, squad movements without numbers.
7: 00 to 9 P. M.—Evening Study. Lecture. Personal Hygiene. Study Assignment. F. A. D. R. covering work done first day.

During Evening Study Period, when subject for lecture is not stated, Battery Commanders will arrange to have Battery Officer for the Day give a talk on some topic pertinent to the scheduled instruction. The Battery Officer can give résumé of the work of the day and clean up all questions and also go over work for coming day, giving hints to aid in preparation of work. Make the evening period more of lecture period than a straight study period.

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Advanced Platoon

6: 45 to 7: 45 A.M.—Inspection.
28 candidates acting as Battery Officers and N. C. O.'s. Remainder of Platoon under Arms.

7: 45 to 8: 45 A.M.—Guard Duty.
Daily rehearse Guard Mount, 20 minutes. Adjutant and Sergeant Major prepare field before period starts.
1st Day—Night Guard Duty. Assignment 80–138.
2d Day—Night Guard Duty. Assignment 80–138.
3d Day—Duties of Sergeants and Corporals. Assgt. 41–80.
4th Day—Commander of the Guard. Assignment M. I. G. D.
5th Day—Officer of the Day.

8: 45 to 9: 45 A.M.—Drill.
1st Day—Manual of Arms. No Marching.
2d Day—Manual of Arms. No Marching.
3d Day—School of the Squad.
4th Day—School of the Squad.
5th Day—School of the Squad.

9: 45 to 10: 45 A.M.—Mathematics.

10: 45 to 11: 15 A.M.—Physical Drill.

12: 30 to 1: 30 P.M.—Mathematics.

1: 30 to 2: 30 P.M.—Drill.
1st Day—Manual of Arms. No Marching.
2d Day—Manual of Arms. No Marching.
3d Day—School of the Squad.
4th Day—School of the Squad.
5th Day—Platoon Drill.

2: 30 to 3: 30 P.M.—Lectures.
1st Day—Nomenclature and Care of Rifle.
2d Day—School of the Squad Drill.
3d Day—Drill by Platoon. Commands in Unison.
4th Day—Drill by Platoon. Commands in Unison.
5th Day—Drill by Platoon. Commands in Unison.

3: 30 to 4: 30 P.M.—Drill.
1st Day—Manual of Arms. Forward March. Battery Halt.
2d Day—Manual of Arms. Forward March. Battery Halt.
3d Day—School of the Squad.
4th Day—School of the Squad.
5th Day—Platoon Drill.

NOTE.—Lectures on Administration of Battery, Methods of Instruction, and Military Ceremonies will be given during advanced week.

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TRAINING SCHEDULE.

	Week ☞	1	2	3	4	5	6	7	8	9	10	11	12	
3	ADMINISTRATION	3	3	4t										
	Army Regulations													
	Battery Administration and Paper Work													
	Field Service Regulations													
	Manual of Courts Martial													
4	ANTI GAS DRILL										5	5	2	
5	CARE AND TRAINING OF HORSES	5	6t	5	5	5	5	6t						
	Entraining and Detraining Horses													
	Hippology													
	Stable Management													
	Simple Cordage													
6	COMMUNICATION	2	2	2	2	2	3t	5	5	6t	5	6t	5	
	Elementary Electricity													
	Liaison													
	Telephones													
	Visual Signalling													
7	CONDUCT OF FIRE	2	2	3	3	6t	5	6t	5	5	11t	11t	10	
	Firing Data													
	Miniature Range													
	Smoke Bomb Practice													
	Terrain Board													
	Use of B. C. Instruments													
8	DISMOUNTED DRILL AND MILITARY COURTESIES	6t	5	5	6t									
9	DRIVING	2	2	3	3	3t	2	5	6t	5	5	5	10	
	Driving Drill and Signals													
	Draft													
	Harnessing and Unharnessing in the Field													
	Harness Fitting													
10	FIELD GUNNERY					5	5	6t	5	6t				
	Dispersion													
	Range Tables													
	The Trajectory													
11	FIRE DISCIPLINE	5	6t	5	5	6t	5	5	6t	5	6t	5	10	
	Firing Battery													
	Gun Laying, Fuze setting, etc													
12	GUN SQUAD	4t	3	2	3t									
	INSPECTION	1	1	1	1	1	1	1	1	1	1	1		
13	MATERIEL	6t	5	6t	6	5	6t	2	2	2				
	Adjustment of Sights													
	Ammunition and Fuzes													
	Description and Care of Materiel													
	Driver and Cannoneer Rolls													
	Entraining and Detraining Materiel													
	Shelter Tents													
14	MOTORS AND TRACTORS													
15	PHYSICAL TRAINING	3	3	3	3	3	3	3	3	3	3	3		
16	PISTOL DRILL AND GUARD DUTY	3	4t	3	4t									
17	RECONNAISSANCE					5	5	5	7	7t	5	6t	5	
	Battery Detail													
	Gun Positions													
	Protection of Guns and Ammunition													
18	RIDING	3	3	3t	2	3	3							
19	TOPOGRAPHY AND ARTILLERY BOARDS	2	2	2	4	3	4t	3	7t	7	6t	5	5	

FIELD INSTRUCTION IN CAMP

NOTE.—Subjects should be studied in the sequence here indicated.

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INSTRUCTION SCHEDULE—FIRST AND SECOND WEEKS

Hour	MONDAY WEDNESDAY FRIDAY	TUESDAY THURSDAY	SATURDAY	
6:45 to 7:45	A, B: Fire Discipline C, D: Gun Squad E, F: Dismounted Drill G, H: Pistol Drill and Guard Duty	A, B: Fire Discipline C, D: Topography E, F: Dismounted Drill G, H: Conduct of Fire	INSPECTION ALL SECTIONS	
7:45 to 8:45	A, B: Pistol Drill and Guard Duty C, D: Fire Discipline E, F: Gun Squad G, H: Dismounted Drill	A, B: Conduct of Fire C, D: Fire Discipline E, F: Topography G, H: Dismounted Drill	1st Week Gun Squad (Test) All Sections	2nd Week Care and Training of Horses (Test) All Sections
8:45 to 9:45	A, B: Riding C, D: Materiel E, F: Fire Discipline G, H: Gun Squad	A, B: Driving C, D: Materiel E, F: Fire Discipline G, H: Topography	1st Week Dismounted Drill (Test) All Sections	2nd Week Fire Discipline (Test) All Sections
9:45 to 10:45	A, B: Gun Squad C, D: Riding E, F: Materiel G, H: Fire Discipline	A, B: Topography C, D: Driving E, F: Materiel G, H: Fire Discipline	1st Week Materiel (Test) All Sections	2nd Week Pistol Drill Guard Duty (Test) All Sections
10:45 to 11:15	Physical Drill All Sections	SAME AS MONDAY	SAME AS MONDAY	
12:30 to 1:30	Administration All Sections	Communication All Sections		
1:30 to 2:30	Care and Training of Horses All Sections	SAME AS MONDAY		
2:30 to 3:30	A, B: Dismounted Drill C, D: Pistol Drill and Guard Duty E, F: Riding G, H: Materiel	A, B: Dismounted Drill C, D: Conduct of Fire E, F: Driving G, H: Materiel		
3:30 to 4:30	A, B: Materiel C, D: Dismounted Drill E, F: Pistol Drill and Guard Duty G, H: Riding	A, B: Materiel C, D: Dismounted Drill E, F: Conduct of Fire G, H: Driving		

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INSTRUCTION SCHEDULE—THIRD WEEK

Hour	MONDAY WEDNESDAY FRIDAY	TUESDAY THURSDAY	SATURDAY
6:45 to 7:45	A, B: Fire Discipline C, D: Pistol Drill and Guard Duty E, F: Driving G, H: Conduct of Fire	A, B: Fire Discipline C, D: Gun Squad E, F: Riding G, H: Topography	Inspection All Sections
7:45 to 8:45	A, B: Conduct of Fire C, D: Fire Discipline E, F: Pistol Drill and Guard Duty G, H: Driving	A, B: Topography C, D: Fire Discipline E, F: Gun Squad G, H: Riding	Riding (Test) All Sections
8:45 to 9:45	A, B: Materiel C, D: Dismounted Drill E, F: Fire Discipline G, H: Pistol Drill and Guard Duty	A, B: Materiel C, D: Dismounted Drill E, F: Fire Discipline G, H: Gun Squad	Materiel (Test) All Sections
9:45 to 10:45	A, B: Pistol Drill and Guard Duty C, D: Materiel E, F: Dismounted Drill G, H: Fire Discipline	A, B: Gun Squad C, D: Materiel E, F: Dismounted Drill G, H: Fire Discipline	Administration (Test) All Sections
10:45 to 11:15	Physical Drill All Sections	SAME AS MONDAY	SAME AS MONDAY
12:30 to 1:30	A, B: Driving C, D: Conduct of Fire E, F: Materiel G, H: Dismounted Drill	A, B: Riding C, D: Topography E, F: Materiel G, H: Dismounted Drill	
1:30 to 2:30	A, B: Dismounted Drill C, D: Driving E, F: Conduct of Fire G, H: Materiel	A, B: Dismounted Drill C, D: Riding E, F: Topography G, H: Materiel	
2:30 to 3:30	Administration All Sections	Communication All Sections	
3:30 to 4:30	Care and Training of Horses All Sections	SAME AS MONDAY	

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INSTRUCTION SCHEDULE—FOURTH WEEK

Hour	MONDAY WEDNESDAY FRIDAY	TUESDAY THURSDAY	SATURDAY
6:45 to 7:45	A Pistol Drill and Guard Duty B C Materiel D E Fire Discipline F G Driving H	A Communication B C Topography D E Fire Discipline F G Riding H	Inspection All Sections
7:45 to 8:45	A Driving B C Materiel D E Pistol Drill and Guard Duty F G Fire Discipline H	A Riding B C Topography D E Communication F G Fire Discipline H	Gun Squad (Test) All Sections
8:45 to 9:45	A Fire Discipline B C Pistol Drill and Guard Duty D E Materiel F G Care and Training of Horses H	A Fire Discipline B C Communication D E Topography F G Care and Training of Horses H	Dismounted Drill (Test) All Sections
9:45 to 10:45	A Care and Training of Horses B C Fire Discipline D E Materiel F G Pistol Drill and Guard Duty H	A Care and Training of Horses B C Fire Discipline D E Topography F G Communication H	Pistol Drill and Guard Duty (Test) All Sections
10:45 to 11:15	Physical Drill All Sections	SAME AS MONDAY	SAME AS MONDAY
12:30 to 1:30	A Conduct of Fire B C Driving D E Dismounted Drill F G Materiel H	A Gun Squad B C Riding D E Dismounted Drill F G Topography H	
1:30 to 2:30	A Dismounted Drill B C Conduct of Fire D E Driving F G Materiel H	A Dismounted Drill B C Gun Squad D E Riding F G Topography H	
2:30 to 3:30	A Materiel B C Care and Training of Horses D E Conduct of Fire F G Dismounted Drill H	A Topography B C Care and Training of Horses D E Gun Squad F G Dismounted Drill H	
3:30 to 4:30	A Materiel B C Dismounted Drill D E Care and Training of Horses F G Conduct of Fire H	A Topography B C Dismounted Drill D E Care and Training of Horses F G Gun Squad H	

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INSTRUCTION SCHEDULE—FIFTH AND SIXTH WEEKS

Hour	MONDAY WEDNESDAY FRIDAY	TUESDAY THURSDAY	SATURDAY	
6:45 to 7:45	A Conduct of Fire B Conduct of Fire C Materiel D Materiel E Fire Discipline F Fire Discipline G Riding H Riding	A Conduct of Fire B Conduct of Fire C Materiel D Materiel E Fire Discipline F Fire Discipline G Driving H Driving	Inspection all Sections	
7:45 to 8:45	A Riding B Riding C Conduct of Fire D Conduct of Fire E Materiel F Materiel G Fire Discipline H Fire Discipline	A Driving B Driving C Conduct of Fire D Conduct of Fire E Materiel F Materiel G Fire Discipline H Fire Discipline	5th Week Fire Discipline (Test) All Sections	6th Week Materiel (Test) All Sections
8:45 to 9:45	A Fire Discipline B Fire Discipline C Care and Training of Horses D Care and Training of Horses E Conduct of Fire F Conduct of Fire G Materiel H Materiel	A Fire Discipline B Fire Discipline C Care and Training of Horses D Care and Training of Horses E Conduct of Fire F Conduct of Fire G Materiel H Materiel	5th Week Driving (Test) All Sections	6th Week Communication (Test) All Sections
9:45 to 10:45	A Materiel B Materiel C Fire Discipline D Fire Discipline E Care and Training of Horses F Care and Training of Horses G Conduct of Fire H Conduct of Fire	A Materiel B Materiel C Fire Discipline D Fire Discipline E Care and Training of Horses F Care and Training of Horses G Conduct of Fire H Conduct of Fire	5th Week Conduct of Fire (Test) All Sections	6th Week Topography (Test) All Sections
10:45 to 11:15	Physical Drill All Sections	SAME AS MONDAY	SAME AS MONDAY	
12:30 to 1:30	A Reconnaissance B Reconnaissance C Riding D Riding E Topography F Communication G Care and Training of Horses H Care and Training of Horses	A Reconnaissance B Reconnaissance C Driving D Driving E Communication F Communication G Care and Training of Horses H Care and Training of Horses		
1:30 to 2:30	A Care and Training of Horses B Care and Training of Horses C Reconnaissance D Reconnaissance E Riding F Driving G Topography H Communication	A Care and Training of Horses B Care and Training of Horses C Reconnaissance D Reconnaissance E Driving F Driving G Communication H Communication		
2:30 to 3:30	A Topography B Communication C Field Gunnery D Field Gunnery E Reconnaissance F Reconnaissance G Field Gunnery H Field Gunnery	A Communication B Communication C Field Gunnery D Field Gunnery E Reconnaissance F Reconnaissance G Field Gunnery H Field Gunnery		
3:30 to 4:30	A Field Gunnery B Field Gunnery C Topography D Communication E Field Gunnery F Field Gunnery G Reconnaissance H Reconnaissance	A Field Gunnery B Field Gunnery C Communication D Communication E Field Gunnery F Field Gunnery G Reconnaissance H Reconnaissance		

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INSTRUCTION SCHEDULE—SEVENTH WEEK

Hour	MONDAY WEDNESDAY FRIDAY	TUESDAY THURDSAY	SATURDAY
6:45 to 7:45	A Conduct of Fire B Conduct of Fire C Topography D Topography E Fire Discipline F Fire Discipline G Driving H Driving	A Conduct of Fire B Conduct of Fire C Materiel D Materiel E Fire Discipline F Fire Discipline G Driving H Driving	Inspection All Sections
7:45 to 8:45	A Driving B Driving C Conduct of Fire D Conduct of Fire E Topography F Topography G Fire Discipline H Fire Discipline	A Driving B Driving C Conduct of Fire D Conduct of Fire E Materiel F Materiel G Fire Discipline H Fire Discipline	Conduct of Fire (Test) All Sections
8:45 to 9:45	A Fire Discipline B Fire Discipline C Reconnaissance D Reconnaissance E Conduct of Fire F Conduct of Fire G Topography H Materiel	A Fire Discipline B Fire Discipline C Reconnaissance D Reconnaissance E Conduct of Fire F Conduct of Fire G Materiel H Materiel	Care and Training of Horses (Test) All Sections
9:45 to 10:45	A Topography B Topography C Fire Discipline D Fire Discipline E Reconnaissance F Reconnaissance G Conduct of Fire H Conduct of Fire	A Materiel B Materiel C Fire Discipline D Fire Discipline E Reconnaissance F Reconnaissance G Conduct of Fire H Conduct of Fire	Field Gunnery (Test) All Sections
10:45 to 11:15	Physical Drill All Sections	SAME AS MONDAY	SAME AS MONDAY
12:30 to 1:30	A Care and Training of Horses B Care and Training of Horses C Driving D Driving E Field Gunnery F Field Gunnery G Communication H Communication	A Care and Training of Horses B Care and Training of Horses C Driving D Driving E Field Gunnery F Field Gunnery G Communication H Communication	
1:30 to 2:30	A Communication B Communication C Care and Training of Horses D Care and Training of Horses E Driving F Driving G Field Gunnery H Field Gunnery	A Communication B Communication C Care and Training of Horses D Care and Training of Horses E Driving F Driving G Field Gunnery H Field Gunnery	
2:30 to 3:30	A Field Gunnery B Field Gunnery C Communication D Communication E Care and Training of Horses F Care and Training of Horses G Reconnaissance H Reconnaissance	A Field Gunnery B Field Gunnery C Communication D Communication E Care and Training of Horses F Care and Training of Horses G Reconnaissance H Reconnaissance	
3:30 to 4:30	A Reconnaissance B Reconnaissance C Field Gunnery D Field Gunnery E Communication F Communication G Care and Training of Horses H Care and Training of Horses	A Reconnaissance B Reconnaissance C Field Gunnery D Field Gunnery E Communication F Communication G Care and Training of Horses H Care and Training of Horses	

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INSTRUCTION SCHEDULE—EIGHTH WEEK

Hour	MONDAY WEDNESDAY FRIDAY	TUESDAY THURSDAY	SATURDAY
6:45 to 7:45	A Reconnaissance B Reconnaissance C Topography D Topography E Conduct of Fire F Conduct of Fire G Driving H Driving	A Materiel B Materiel C Reconnaissance D Reconnaissance E Conduct of Fire F Conduct of Fire G Driving H Driving	Inspection All Sections
7:45 to 8:45	A Driving B Driving C Topography D Topography E Reconnaissance F Reconnaissance G Conduct of Fire H Conduct of Fire	A Driving B Driving C Reconnaissance D Reconnaissance E Materiel F Materiel G Conduct of Fire H Conduct of Fire	Topography (Test) All Sections
8:45 to 9:45	A Conduct of Fire B Conduct of Fire C Reconnaissance D Reconnaissance E Topography F Topography G Communication H Communication	A Conduct of Fire B Conduct of Fire C Materiel D Materiel E Reconnaissance F Reconnaissance G Communication H Communication	Fire Discipline (Test) All Sections
9:45 to 10:45	A Communication B Communication C Conduct of Fire D Conduct of Fire E Topography F Topography G Reconnaissance H Reconnaissance	A Communication B Communication C Conduct of Fire D Conduct of Fire E Reconnaissance F Reconnaissance G Materiel H Materiel	Driving (Test) All Sections
10:45 to 11:15	Physical Drill All Sections	SAME AS MONDAY	SAME AS MONDAY
12:30 to 1:30	A Fire Discipline B Fire Discipline C Driving D Driving E Field Gunnery F Field Gunnery G Topography H Reconnaissance	A Fire Discipline B Fire Discipline C Driving D Driving E Field Gunnery F Field Gunnery G Topography H Reconnaissance	
1:30 to 2:30	A Field Gunnery B Field Gunnery C Fire Discipline D Fire Discipline E Driving F Driving G Topography H Reconnaissance	A Field Gunnery B Field Gunnery C Fire Discipline D Fire Discipline E Driving F Driving G Topography H Reconnaissance	
2:30 to 3:30	A Topography B Reconnaissance C Communication D Communication E Fire Discipline F Fire Discipline G Field Gunnery H Field Gunnery	A Reconnaissance B Reconnaissance C Communication D Communication E Fire Discipline F Fire Discipline G Field Gunnery H Field Gunnery	
3:30 to 4:30	A Topography B Reconnaissance C Field Gunnery D Field Gunnery E Communication F Communication G Fire Discipline H Fire Discipline	A Reconnaissance B Reconnaissance C Field Gunnery D Field Gunnery E Communication F Communication G Fire Discipline H Fire Discipline	

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INSTRUCTION SCHEDULE—NINTH WEEK

Hour	MONDAY WEDNESDAY FRIDAY	TUESDAY THURSDAY	SATURDAY
6:45 to 7:45	A Topography B Topography C Reconnaissance D Reconnaissance E Conduct of Fire F Conduct of Fire G Driving H Driving	A Materiel B Materiel C Topography D Topography E Conduct of Fire F Conduct of Fire G Driving H Driving	Inspection all Sections
7:45 to 8:45	A Driving B Driving C Reconnaissance D Topography E Topography F Materiel G Conduct of Fire H Conduct of Fire		Reconnaissance (Test) All Sections
8:45 to 9:45	A Conduct of Fire B Conduct of Fire C Topography D Materiel E Reconnaissance F Topography G Communication H Communication		Communication (Test) All Sections
9:45 to 10:45	A Communication B Communication C Conduct of Fire D Conduct of Fire E Reconnaissance F Topography G Topography H Materiel		Field Gunnery (Test) All Sections
10:45 to 11:15	Physical Drill All Sections	SAME AS MONDAY	SAME AS MONDAY
12:30 to 1:30	A Fire Discipline B Fire Discipline C Driving D Driving E Field Gunnery F Field Gunnery G Reconnaissance H Topography		
1:30 to 2:30	A Field Gunnery B Field Gunnery C Fire Discipline D Fire Discipline E Driving F Driving G Reconnaissance H Topography		
2:30 to 3:30	A Reconnaissance B Topography C Communication D Communication E Fire Discipline F Fire Discipline G Field Gunnery H Field Gunnery		
3:30 to 4:30	A Reconnaissance B Topography C Field Gunnery D Field Gunnery E Communication F Communication G Fire Discipline H Fire Discipline		

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INSTRUCTION SCHEDULE—TENTH AND ELEVENTH WEEKS

Hour	MONDAY WEDNESDAY FRIDAY	TUESDAY THURSDAY	SATURDAY	
6:45 to 7:45	A–H: Topography / Reconnaissance / Conduct of Fire / Driving	A–H: Topography / Reconnaissance / Conduct of Fire / Driving	Inspection All Sections	
7:45 to 8:45	A–H: Driving / Topography / Reconnaissance / Conduct of Fire	A–H: Driving / Topography / Reconnaissance / Conduct of Fire	10th Week Topography (Test) All Sections	11th Week Communication (Test) All Sections
8:45 to 9:45	A–H: Conduct of Fire / Anti Gas Drill / Topography / Reconnaissance	A–H: Conduct of Fire / Anti Gas Drill / Topography / Reconnaissance	10th Week Conduct of Fire (Test) All Sections	11th Week Conduct of Fire (Test) All Sections
9:45 to 10:45	A–H: Reconnaissance / Conduct of Fire / Anti Gas Drill / Topography	A–H: Reconnaissance / Conduct of Fire / Anti Gas Drill / Topography	10th Week Fire Discipline (Test) All Sections	11th Week Reconnaissance (Test) All Sections
10:45 to 11:15	Physical Drill All Sections	SAME AS MONDAY	SAME AS MONDAY	
12:30 to 1:30	A–H: Fire Discipline / Driving / Conduct of Fire / Communication	A–H: Fire Discipline / Driving / Conduct of Fire / Communication		
1:30 to 2:30	A–H: Communication / Fire Discipline / Driving / Conduct of Fire	A–H: Communication / Fire Discipline / Driving / Conduct of Fire		
2:30 to 3:30	A–H: Conduct of Fire / Communication / Fire Discipline / Anti Gas Drill	A–H: Conduct of Fire / Communication / Fire Discipline / Anti Gas Drill		
3:30 to 4:30	A–H: Anti Gas Drill / Conduct of Fire / Communication / Fire Discipline	A–H: Anti Gas Drill / Conduct of Fire / Communication / Fire Discipline		

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INSTRUCTION SCHEDULE—TWELFTH WEEK

Field Instruction in Camp

Anti-gas Drill	(2 Hours)
Communication	(5 Hours)
Conduct of Fire	(10 Hours)
Driving	(10 Hours)
Fire Discipline	(10 Hours)
Reconnaissance	(5 Hours)
Topography and Artillery Boards	(5 Hours)

SCHEDULE
FIELD INSTRUCTION IN CAMP

Saturday. Assignment of batteries to tents and matériel.
Assignment to duties: Equipment issued.
Instruction in arrangement of cots and equipment in tents.
Explanation of routine camp duties, police, sanitation, limits of camp.

Sunday.

6:45 to 7:45 Drivers—Harness drill, harness fitting.
Cannoneers—Care of matériel.
B. C. Detail—Telephones.

7:45 to 10:15 Entire battery march to drill ground.
Drivers—Battery mounted with limbers and caisson sections.
Cannoneers—Firing battery.
B. C. Detail—Reconnaissance.

10:15 to 11:15 Stables and care of matériel.

12:30 to 1:30 Battery mounted.
B. C. Detail—Signaling.

1:30 to 2:30 Drivers—Battery mounted.
Cannoneers—Firing battery.
B. C. Detail—Signaling and telephones.

2:30 to 4:30 Entire Battery—Draft over varied ground.

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Monday.

6:45 to 7:45	Entire Battery—Making rolls. All men make both kinds. All men bring complete field kit.
7:45 to 8:45	Drivers—Harnessing and packing rolls. Cannoneers—Packing rolls and care of matériel in preparation for march. B. C. Detail—Saddling and packing rolls.
8:45 to 10:15	Drivers and Cannoneers—Battery mounted paying particular attention to unlimbering to go into action and limbering. B. C. Detail—Sketching, signaling, and telephones.
10:15 to 11:15	Stables and care of matériel.
12:30 to 1:30	Entire Battery—Battery mounted. Firing battery.
1:30 to 4:30	Entire Battery—Draft over varied ground.

Tuesday.

6:45 to 10:15	Entire Battery—Short march with full pack. Reconnaissance, occupation of position, firing battery.
10:15 to 11:15	Stables and care of matériel.
12:30 to 1:30	Entire Battery—Battery mounted.
1:30 to 2:30	Entire Battery—Harnessing and harness fitting.
2:30 to 4:30	Drivers—Battery mounted. Cannoneers—Firing battery. B. C. Detail—Signaling, telephones, and sketching.

Wednesday.

6:45 to 10:15	Entire Battery—Short march with full pack. Reconnaissance, occupation of position, firing battery.
10:15 to 11:15	Stables and care of matériel.
12:30 to 4:30	Battery cleaning. Adjustment of sights and quadrants.

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Thursday.	
6: 45 to 4: 30	Entire Battery—March with full pack to firing point, reconnaissance and occupation of positions, field firing, establish camp, break camp, return.
Friday.	Same as Thursday.
Saturday.	Inspection, turn in equipment, lecture on French matériel.

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CARE AND TRAINING OF HORSES

Books of reference: Vol. II, Drill and Service Regulations for Field Artillery, Manual for Stable Sergeants, Manual for Army Horseshoers. All paragraph numbers and their abbreviations refer to these textbooks.

First Week —(5 hours). Conferences.

1. **Points of the Horse. (Pars. 119–121, M. S. S.)**
   Note—(Draw on blackboard figure of horse with names and points.)

2. **Skeleton of the Horse.**
   Note—(Use figure drawn in Lecture 1. Give names and show position of bones forming the points. Notice particularly the framework of bones supporting the withers, back, loin, shoulders, elbow, and stifle).

3. **Assignment: (Pars. 119–121, M. S. S. Figure 1, M. S. S.)**
   Note—(Horse should be used and candidates called upon to show points and bone construction of the framework supporting the points.)

4. **Types of Artillery Horses.**
   Note—(Two horses should be used, one having the desirable conformation of an Artillery Horse and the other one the undesirable. These differences should be emphasized.)

5. **Practical Application.**
   Note—(From a selection of twenty horses varying in conformation, have each class form a team and two individual mounts, matching the pairs in conformation, weight, and temperament.)

Second Week —(6 hours). Conferences.

1. **Rules for the Care of the Horse. Assignment: Par. 591, D. & S. R. F. A.**

2. **Age of Horses as Indicated by Teeth.**
   Note—(Drawings should be made of the teeth as they are seated in the upper and lower jaw. Also a longitudinal section of a central lower incisor, and cross section of same tooth showing surfaces as they appear at different ages.)

3. **Practical Application.**
   Note—(This period should be devoted to estimating the ages of six horses whose ages vary from five to ten years. Particular attention to the "Cups," dental star, and shape of wearing surface.)

4. **Foot. (Chap. IV, M. A. H.)**
   Note—(Make drawings of the bones of the foot, wall, ground surface of the hoof, and sensitive hoof, naming parts.)

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5. **Shoeing. (Chap. V., M. A. H.)**

Note—(Demonstrate use of tools, preparation of foot for shoeing, special shoes, and fitting, using horse and blacksmith tools.)

6. **Test.**

Third Week—(5 hours). Conferences.

1. **Practical Shoeing. Assignment: (Chapters IV and V, M. A. H. Pars. 611–613, D. S. F. A.)**

Note—(Battery is carried to Blacksmith shop for a practical demonstration of shoeing. Explain each step in shoeing.)

2. **Simple Cordage and Construction of the Picket Line. Assignment: Pars. 141–243, M. S. S.—594, D. & S. R. F. A.**

Note—(Just the knots used in tying to picket line and stalls are used.)

3. **Cordage, Picket Line, and Restraint.**

Note—(Each candidate should tie a horse to picket line and in the stall. Show class the picket line and discuss construction of same. Practical demonstration of Pars. 228–243, M. S. S. Care should be used not to excite the animal when applying the apparatus of restraint.)

4. **Grooming.**

5. **Grooming. Assignment: Pars. 603–604, D. & S. R. F. A.**

Fourth Week—(5 hours). Conferences.

1 and 2. **Practical Grooming. Assignment: Pars. 605–606, D. & S. R. F. A.**

Note—(Groom horse by detail to facilitate supervision, the candidates must be required to change promptly at the command.)

3 and 4. **Practical Grooming.**

Note —(Grooming by detail. Time devoted to each part as prescribed in Par. 605, D. & S. R. F. A. Instructor should inspect horses as per Par. 606, D. & S. R. F. A.)

5. **General Principles of the Care and Conditioning of Horses. Assignment: Pars. 590, 592, 593, 595, 601, 602, 607, 608, 609, D. & S. R. F. A.**

Fifth Week—(5 hours). Conferences.

1. **Common Diseases, Wounds, and Lameness.**

Note—(Each subject should be taken up in the following order: definition, cause, prevention, laying particular stress on prevention.)

2 and 3. **Policing Stables and Corrals.**

4 and 5. **Hygiene. Assignment: Chapter XVII, M. S. S.**

Sixth Week—(5 hours). Conferences.

1. **Feeds and Feedings. Assignment: Pars. 596–600, D. & S. R. F. A.**

2. **Practical Feeding.**

Note—(Have each section feed, water, and tie in stalls.)

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3 and 4. Soundness.

Note—(Conduct a thorough and systematic examination for soundness, using an unsound horse.)

5. Care of Horse on March and in the Field. Assignment: 623–633, D. & S. R. F. A.

Seventh Week—(6 hours).

1. **Common Medicines, Action, Uses and Methods of Administering.**

2. **Condition and Exercises. Assignment: Pars. 614–632, D. & S. R. F. A.**

3. **Stable Administration and Paper Work.**

Note—(Show the class how to fill out the following forms: Morning Report, Descriptive Card of Public Animals, Survey Report, Sick, Forage, and Shoeing Books, and Requisition for Forage.)

4. **Field Work. Entraining and Detraining Horses.** (Using American Stock Cars.)

5. **Field Work. Entraining and Detraining Horses.** (Using French Stock Cars.)

6. **Test.**

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COMMUNICATION

The outline below was followed in the course in Communication:

First Week—(2 hours).

1. **Conference.** ("Liaison in Modern Warfare.")
2. **Drill. Semaphore.** Letters A–G, Numerals 1–7.

Assignment—Signal Book, U. S. Army, 1916, Pars. 44 to 46, inc., or Manual for Noncommissioned Officers and Privates of Field Artillery, Vol. II, p. 219.

Second Week—(2 hours).

1. **Drill. Semaphore.** Letters H O W Z, Numeral 8.
2. **Drill. Wigwag.** E I S H

Assignment: Signal Book, U. S. Army, 1916, Pars. 23 to 25 inc. Manual for Noncommissioned Officers and Privates of Field Artillery, Vol. II, p. 217.

Third Week—(2 hours). Drill.

1. **Semaphore (30 minutes)**
   Third Group—Letters K L M N
   Wigwag (30 minutes).
   Second Group—Letters T M O
   Numerals 1 2 3 4 5
   Note—(Review letters of first Group.)
2. **Semaphore (30 minutes).**
   Fourth Group—Letters R U N T
   Fifth Group—Letters I X Y P
   Numeral o
   Wigwag (30 minutes).
   Third Group—Letters A W J U V
   Note—(Review letters of first two groups.)

Fourth Week—(2 hours).

1. **Drill. Semaphore (30 minutes).**
   Sixth Group—Letters J Q S V
   Numeral o
   Wigwag (30 minutes).
   Fourth Group—Letters N D B C X
   Numerals 6 7 8 9 o
2. **Conference and Drill.**
   General Description of Service Buzzer (30 minutes).

Note—(While not issued to F. A., the buzzer is used as a means of teaching the I. M. C. by sound. (1) Nomenclature of instrument and brief explanation of

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practical function of each part. (2) Method of connection and operation of telephone and buzzer elements.

Buzzer (30 minutes).

Fifth Week—(2 hours). Drill.

1. **Wigwag (30 minutes).**

Letters L F Y 2, G K P R Z

Note—(Review alphabet and numerals.)

Buzzer (30 minutes).

Note—(A number of words, preferably short ones, will be sent by instructor and recorded by candidates.)

2. **Semaphore (30 minutes).**

Note—(Divide battery into pairs and assign two pairs to work together from signaling stations placed far enough apart so that communication by voice may not be carried on easily. Have one man act as operator and the other as recorder alternating in the positions.)

Wigwag (30 minutes).

Note—(Same as above.)

Sixth Week—(3 hours).

1. **Semaphore (30 minutes.)**

Same as above.

Buzzer (30 minutes).

Note—(Assign various candidates to send previously prepared messages by buzzer while others record. Instructor must be careful to see that candidate operator sends correctly and promptly note and call attention to any errors made. Candidates required to turn in their records of what is sent.)

2. **Wigwag (30 minutes).**

Same as preceding lesson.

Buzzer (30 minutes).

Note—(Same as preceding lesson. Messages to include use of common abbreviations and artillery code.)

Assignment: Signal Book, U. S. Army, 1916, Par. 49, Manual for Noncommissioned Officers and Privates of Field Artillery, Vol. II, pp. 223 and 224.

3. **Text. Semaphore.**

Note—(Test will be conducted as follows. The battery will be divided equally and the candidates paired. One man of each pair will be designated as reader and the other as recorder. These pairs will be placed far enough apart so that they will not be within speaking distance of each other. The reader will face the signaler and the recorder will face in the opposite direction. It will be the duty of the recorder merely to write down the letters as they are called by the reader. The signaler, either the instructor or some other well qualified operator, will be located in plain view of all students. He will be careful to maintain a

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uniform speed and to make his characters accurately. The test will consist of a block of 40 letters arranged in groups of five, as follows

S N O X T
A I V E R
B M A P U
R E Z C G
Etc.

The signaler will make interval at the end of each group of five letters. The entire block should be sent in one minute—not faster. Three different blocks will be sent and the candidate allowed to turn in any one of the three which he may desire. When the first half of the battery has been given the test, the positions of reader and recorder will be reversed and the second half given a similar test. To satisfactorily qualify a candidate should make not more than 5% errors in receiving.)

Seventh Week—(6 hours). Conferences.

1–5. **Elementary Electricity.**
6. **Review.**

Eighth Week—(6 hours). Conferences.

1 and 2. **Elementary Electricity.**
3. **Review of preceding lessons.**
4. **The Theoretical Buzzer and Telephone.**
5. **Adjustment and location of faults.**
6. **Field Messages.**

Note—(1) Blackboard illustration and explanation of proper form.
(2) Candidates required to write and submit messages which will be read and criticized by the instructor for benefit of class.

Assignment: Signal Book, U. S. Army, 1916, part XVII.

Ninth Week—(6 hours).

1. **Drill.**
   Buzzer.

Note—(Field messages will be used as above. All available buzzers will be used in order to give candidates practice in both sending and receiving.)

2. **Conference.**
   Field Wiring, Splices, etc.
3. **Conference.**
   Monocord Switchboard.
4. **Field Work.**
   Camp Telephone and Monocord Switchboard.

Note—(A practical demonstration of the operation of these instruments will be given by instructor. Several telephones and buzzers should be connected to the switchboard in order that the various methods of calling from one instrument to the other may be demonstrated. Candidates will be given an opportunity to examine the instruments and to ask questions.)

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5. Conference.

Review of Elementary Electricity. Instructor will make sure that members of his sections understand the simplest theoretical diagrams for ordinary buzzer, for ordinary telephone, and understand the principles of electromagnets and general mechanics of electricity.

6. Test. Elementary Electricity.

Tenth Week—(4 hours).

1. Field Work.
Establishment of Buzzer and Telephone Stations for a Battery.

Note—(The Monocord switchboard will be used at the central station and a pre-arranged set of messages transmitted. Visual signaling will be established at the same time and duplicate messages will be sent by this method with a competitive element introduced to stimulate interest and to demonstrate the advantages and disadvantages of the two systems.)

2. Conference.
Location, Operation, and Coördination of Visual Signaling Stations.

3. Conference.
The Projector, Nomenclature, and Adjustments.

This lecture is to be accompanied by a demonstration of the projector. Minor adjustments will be made as indicated.

4. Conference.
Projector, Operation.

Eleventh Week—(4 hours).

1. Conference.
The Very Pistol, Flares, Rockets, Shutter Panels.

2. Conference.
Communication with Aeroplane.

3. Conference.
The artillery net, including an explanation of the limitations of the various devices for communication.

4. Test.

Twelfth Week.

1–5. Field Instruction in Camp.

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CONDUCT OF FIRE

Note—(Numbers, unless otherwise specified, refer to paragraphs in the Drill and Service Regulations for Field Artillery.)

First Week—(2 hours).

1. **Conference.**

Note—(Explain briefly the object and sequence of instruction. 833–837. Method of deriving the mil, conversion of the mil into linear measurement and the reverse. Explain indirect laying, 985–988, the general principles involved, and discuss generally the various elements of the initial data, 955–984, showing why each is given.)

Assignment. Pars. 833–837, 955–988, D. & S. R. F. A.

2. **Conference.**

Note—(In making assignments, emphasize the important points in the next day's lesson. Require exact knowledge of the three kinds of battery positions and the three kinds of defilade, 1055–1094, and a general knowledge of the duties of officers and the selection of observing stations. Have candidates practice the designation of objectives, 1142–1154, and of aiming points, 1159–1167.)

Assignment. Pars. 1055–1094, 1142 –1154, 1159–1167, D. & S. R. F. A.

Second Week—(2 hours).

1. **Conference.**
Computation of Firing Data—Parallel Method—Deflection.

Note—(Explain parallax and obliquity, using string method to show their meaning graphically. 1155–1158. Show how B. C. takes station away from guns and measures the angle A. Place B. C. on line of guns to the left with aiming point directly in rear. Construct angle at guns (deflection) which he wishes to compute, and construct an equal angle at the B. C. station by parallel lines. Demonstrate that in this case angle A plus target offset plus aiming point offset equals deflection. Compute offset by dividing B. C. directing piece line by ranges from B. C. in thousands, no obliquity. Offsets are always laid off away from the guns. Solve the problem. Give answer in nearest multiple of 10. 1207).

Assignment. Pars. 1155–1158, 1196–1197, 1207, D. & S. R. F. A.

2. **Conference.**
Computation of Firing Data, Deflection Continued.

Note—(Parallel method. B. C. on line of guns, placing aiming point in different parts of the four quadrants. The obliquity factor for the aiming point offset is then determined by the number of mils the B. C.—A. P. line is off the normal to the B. C.—guns line at the B. C. station. No interpolation for obliquity factors will be used at any time. Solve problem and give one to class.)

Assignment. Two problems in calculating deflection, no obliquity.

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Third Week—(3 hours).

1. **Conference.**
Computation of Firing Data—Deflection.

Note—(Place guns at center of four quadrants from B. C. station so as to give obliquity to the target offset, and place A. P. on normal to B. C.-gun line so there is no obliquity for the A. P. offset. Divide B. C.-gun line by range from B. C. to target in thousands and correct for obliquity. Obliquity factor determined by number of mils B. C.-target line is off normal to B. C.-gun line at B. C. station. Solve problem. Then solve problem in which both A. P. offset and T. offset must be corrected for obliquity. Give problem to class.)

Assignment. Two problems in deflection computation, obliquity of A. P. offset only.

2. **Conference.**
Computation of Firing Data—Deflection Difference.

Note—(Explain meaning of parallel sheaf and show that it may be obtained by a deflection difference equal to the parallax of one platoon front **at the battery** subtended at aiming point. Divide a platoon front (twenty yds.), by range from guns to A. P. and correct for obliquity. The obliquity factor is determined by the number of mils the line guns A. P. is off the line guns-target, because the latter line is perpendicular to the line of guns (assumed). For ordinary targets the deflection difference for parallel fire is increased by ten. Give problem in deflection and deflection difference.)

Assignment. Two problems in deflection computation, obliquity of both A. P. and T. offsets. Pars. 1187–1195, 1226, D. & S. R. F. A.

3. **Conference.**
Computation of Firing Data—Range and Site.

Note—(Range from guns often differs from range from B. C. station. Show graphically, by right triangle, that the difference is computed by multiplying the B. C. gun line by proper obliquity factor. The gun-target range is used by guns. Give problem. Explain meaning of site and of 300 basis. Calculate simple problem in site from one point, changing difference in elevation in yards to site and the reverse. Problem. Use logical method, no formula.)

Assignment. Pars. 972–975, 1208–1210, D. & S. R. F. A. Problem in deflection and deflection difference.

Fourth Week—(3 hours).

1. **Conference.**
Computation of Firing Data—Site.

Note—(Compute site for guns from data obtained at B. C. station. No formulas. Compute difference in elevation in yards between B. C. station and target and between B. C. station and guns, and from this the difference in yards between guns and target. Divide difference thus found by the computed range from guns to target in thousands. Explain graphically. Give problems. One problem in complete firing data.)

Assignment. Problem in deflection, deflection difference, and range. One simple site problem.

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2. **Conference.**
Computation of Firing Data—Review.

Note—(Have candidates solve several complete problems in firing data, placing guns and aiming point in different positions. Include corrector and method of fire. Try to straighten out difficulties in this hour.)

Assignment. Complete problem in firing data.

3. **Field Work.**
Observation of Fire.

Note—(Have candidates prepare by reading assignment. Visit to smoke bomb range or service range. Illustrate time and percussion fire, opening and closing sheaf, heights of burst, effects of changes of corrector, site, and range observation of overs, shorts, and doubtfuls, and obtaining of bracket in range.)

Assignment. Pars. 989–996, 1003, 1215–1224, 1227–1258, D. & S. R. F. A.

Fifth Week—(6 hours).

1. **Conference.**
Blackboard Firing. Computation of Firing Data.

Note—(Explain process of adjustment. Special emphasis on proper sensings. Assignments cover kinds of fire, height of burst, method of fire and range.)

Assignment. Pars. 1259–1280, 1283–1287, D. & S. R. F. A.

2. **Conference.**
Computation of Firing Data—Clearing the Mask.

Note—(No formula. Use graphic method, simply computing height of crest in mils and height of trajectory at crest in mils and taking the difference. Show candidates simple method of remembering angles of departure for various ranges, and that the drop for any range is equal to the angle of departure for that range.)

Assignment. Problem in computing firing data.

3. **Conference.**
Review of last hour's work and calculation of minimum range.

Note—(Require all problems to be worked in same way each time. Give site of crest and target and range to target, calculate minimum range.)

Assignment. Two problems in clearing of mask, one with mask near guns, one with mask near target. Pars. 1172–1176, D. & S. R. F. A.

4. **Conference.**
Blackboard Firing.

Note—(Discuss briefly the method of bracketing, applying it to both range and height of burst. Take a few simple cases to show when adjustment has been completed. Assignment covers basic principles of bracketing.)

Assignment. Pars. 1283–1295, 1300, 1303, 1307–1309, 1311, 1321, 1328, 1330, 1339, D. & S. R. F. A.

5. **Conference.**
Computation of Firing Data—Review.
Assignment. Problems covering all work in computation of firing data.

6. **Test.**

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Sixth Week—(5 hours).

1. **Conference.**
   Discussion of Test. Measurement of Angles without Instruments.

Note—(Have candidates calibrate hands, holding them directly to side. Quick methods of measuring angles of 3200 and 1600 mils, by alignment and squared edge.)

2. **Conference.**
   Terrain Board or Blackboard Firing.

Note—(Assignments refer to adjustment of deflection, 964, 1283–1302, distribution, 1303–1306, and height of burst, 1307–1320. Candidates are just beginning conduct of fire and need encouragement. Allow them to complete command before stopping them, and usually have one man complete a problem.)

Assignment. Pars. 964, 1283–1320, D. & S. R. F. A.

3. **Conference.**
   Nomenclature and Use of Scissors Instrument.

Note—(Set up instrument, give names of principal parts, explain use, and measure angles. Show candidates which hand should be used for different adjustments to save time and obtain more accurate results. Check up calibration of B. C. rulers with instrument.)

Assignment. Calibration of B. C. rulers.

4. **Field Work.**
   Field Computation of Firing Data. Mechanical Computation.

Note—(Have at least three scissors instruments in hands of candidates. Turn instruments calibrated clockwise upon target first. Offsets computed without use of pencil. All candidates using B. C. rulers, with work checked by instruments.)

Assignment. Problem in clearing the mask, with drawing.

5. **Conference.**
   Terrain Board.

Note—(Assignment refers to adjustment of range and includes very difficult work. Considerable time should be spent in bringing out the points of greatest importance and in clearing up difficulties. Show on the blackboard and on the terrain board the reasons for paragraphs causing difficulty. Omit fire for demolition.)

Assignment. Pars. 1223–1224, 1321–1345, D. & S. R. F. A.

Seventh Week—(6 hours).

1. **Conference.**
   Terrain Board.

Note—(Lay stress on proper sequence of commands and require commands to be given in the language of the telephone. When errors have been made, require that they be corrected in the next command, not overlooked, on the assumption that a command once given has been set on the gun. Assignment refers to method of fire. Take up work in fire for demolition.)

Assignment. Pars. 1218, 1221, 1270, 1346–1352, D. & S. R. F. A. Review Pars. 1321–1345.

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2. **Field Work.**
Field Computation of Firing Data. Use of B. C. Instruments.

Note—(Use a number of scissors instruments in all this work. Require independent work and have a candidate explain parts of problem worked. Insist on uniform methods and accuracy.)

Assignment. A short written quiz on the scissors instrument to be answered during evening study period and with the assistance of others if necessary.

3. **Conference.**
Terrain Board.

Note—(Assignment refers to fire for effect. Range, 1354–1365, Heights of Burst, 1366–1371, Distribution, 1372–1382, Method of Fire, 1383–1393. Have questions ready for a review of these paragraphs.)

Assignment. Pars. 1354–1393, D. & S. R. F. A.

4. **Conference.**
Terrain Board of Blackboard Firing. Review.

5. **Conference.**
Nomenclature and Operation of the Aiming Circle. Computation of Firing Data.

Note—(Aiming circle is primarily an angle-measuring instrument. While instrument is being used by part of the class, explain graphically reciprocal laying and require solution of problems involving it.)

Assignment. Par. 967, D. & S. R. F. A. Hand in drawing to illustrate method.

6. **Test.**

Eighth Week—(5 hours).

1. **Field Work.**
Miniature Range.

Note—(Miniature range operated entirely by candidates. Show telephone connections, explain the range, and show how the spotters are used in conforming to commands. Regulations for height of burst must be clearly understood.)

Assignment. Pars. 1398–1413, D. & S. R. F. A. Targets.

2. **Field Work.**
Field Computation of Firing Data.

Note—(Assignment refers to laying on burst and the use of B. C. telescope as an aiming point.)

Assignment. Pars. 968, 1203, D. & S. R. F. A.

3. **Conference.**
Terrain Board.

Note—(Assignment refers to targets with respect to terrain, dead space, firing on targets on slopes. Spend some time in illustrating on blackboard.)

Assignment. Pars. 1413–1417, D. & S. R. F. A.

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4. **Field Work.**
Field Computation of Firing Data. Nomenclature and Operation of Range Finder.

Note—(Instruction as follows. Theory and operation of the range finder, using diagrams on blackboards. (Pages 63–66, Handbook of Fire-control Instruments.) Explanation and nomenclature of principal parts. Three personal adjustments. Operation by candidates, others computing firing data.)

5. **Field Work.**
Miniature Range.

Note—(Require commanding tone of voice in giving commands. Appoint a recorder for each Battery Commander and have him keep record on proper blank. Put observation blanks in hands of all candidates and require each to keep record of his own sensings for several problems each day. It takes little time to check over these sensings and is of great benefit to candidates. Battery Commander may consult recorder in fire for demolition. Assignment refers to number of sensings required for establishment of bracket, use of drop-back of 100 yards.)

Assignment. Pars. 990, 1250, 1259, 1266, 1324, 1335, 1339, 1345, 1355, 1359–1363, D. & S. R. F. A.

Ninth Week—(5 hours).

1. **Field Work.**
Field Computation of Firing Data. Use of B. C. Instruments.

Note—(Have scissors instruments, aiming circle, and range finder in hands of candidates, and rotate them in operating instruments. Solve problem in computation of firing data, using B. C. station as aiming point.)

2. **Conference.**
Terrain Board.

Note—(Give a problem in demolition during each period. Arrange to have the opening salvo in time fire either mixed or bracketing occasionally. No cross fire on first salvo should be given yet. Assignment is a review of corrector changes.)

Assignment. Pars. 1308–1309, 1318, 1338, 1368–1369, 1415.

3. **Conference.**
Map Firing. (Instruction Memorandum 7-D).

Note—(Follow method of instruction laid down in memorandum. Provide each member of section with map, and require drawing boards, sharp pencil, protractor, and ruler. Explain by diagram on blackboard the process of computing firing data from map and select suitable points on maps for candidates to use in solving problem for next day. Lay stress on importance of this method of computation in the present war.)

4. **Conference.**
Map Firing. (Instruction Memorandum 7-D.)

Note—(Discussion of problem solved for day. Use of gridded map in computation of complete problem during hour. Include clearing of mask and all data for opening fire.)

Assignment. Computation of firing data from map.

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5. **Field Work.**
Miniature Range.

Note—(Assignment refers to shorts and overs, a study of sensings, including lost-overs. Be careful to allow no sensings of shorts on bursts higher than lows.)

Assignment. Pars. 1262, 1264, 1265, 1268, 1269, 1271–1274, 1276, 1333, 1353–1357, D. & S. R. F. A.

Tenth Week—(11 hours).

1. **Field Work.**
Field Computation of Firing Data.

Note—(Take new position for B. C. station. Place guns behind a crest. Have candidates determine position of guns by quick computation. Having decided upon this position for whole class by comparison of results, have candidates compute complete data for opening fire.)

Assignment. Problem in minimum range and problem in clearing mask.

2. **Field Work.**
Smoke Bomb Practice.

Note—(Explain that smoke bomb range is conducted just like miniature range. Candidates will operate range under command of sergeant at targets. All sensings made in clear tone. Try to give candidates as much confidence as possible, but keep close record of errors. Grade each candidate on his problem. Assignment refers to adjustment on moving targets.)

Assignment. Pars. 1341, 1358, 1360, 1392, 1404, D. & S. R. F. A.

3. **Conference.**
Compass Laying.

Note—(Nomenclature and use of compass. Explain, with diagrams, methods of measuring and correcting for the magnetic variation of a compass, how to find a magnetic bearing with or without a map, and the work of the B. C. in computing a deflection.

4. **Conference.**
Compass Laying.

Note—(Explain graphically the work of the executive in giving a deflection to each gun, using a compass as an aiming point.

Assignment. Locate for candidates two points on the map, representing positions of gun and target. State the magnetic variation of your compass. Have candidates compute magnetic bearing of target from guns.

5. **Field Work.**
Terrain Board.

Note—(Continue use of observers' blanks for some problems. Spend most of the time in firing, with short discussions of problems fired.)

6. **Conference.**
Computation of Firing Data.

Note—(Explain by diagram the effect upon sensing for height of being nearer to target than the guns, and the reverse. Give problem. Explain in like manner the effect upon sensing for direction and range of being to the right or left of the line of fire. No problem.)

Assignment. Problem in shifting fire from one target to another at different direction, site, and range. Pars. 1215, 1345, 1351, 1407, D. & S. R. F. A.

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7. **Field Work.**
Smoke Bomb Practice.

Note—(Assignment refers to volley fire sweeping.)
Assignment. Pars. 1007, 1372–1381, D. & S. R. F. A.

8. **Field Work.**
Field Computation of Firing Data. Use of B. C. Instruments.

Note—(Assign a target calling for volley fire sweeping and show how to solve it in two ways.)

9. **Field Work.**
Smoke Bomb Practice.

10. **Conference.**
Terrain Board or Blackboard Firing.

Note—(The object of this hour's work is to clear up difficulties encountered in the smoke bomb practice of the week. Give problems on terrain board to illustrate these points. A probable example of weakness is the handling of the sheaf in case of four graze bursts on the first salvo, (a) near the base of target, (b) two mils or more above base of target, (c) 10 mils or more below base of target.)

11. **Test.**

Eleventh Week—(11 hours).

1. **Field Work.**
Smoke Bomb Practice.

Note—(During this week's work, the whistle should be blown on candidates for making serious errors in sensings or commands. The new Battery Commander will use his own sensings in continuing problem. Assignment refers to allowance for drift, wind, and the movement of targets across the field of fire at different rates and angles.)

Assignment. Pars. 1183–1184, D. & S. R. F. A.

2. **Conference.**
Use of Compass and Map in Laying for Direction.

Note—(Work in groups. Each candidate group will need map, compass, protractor, range scale, pin, and string. First, determine the magnetic variation of compass. Then assign map location of guns and target. Compute bearing for guns. Assume executive located with each group. Give a deflection to each gun.)

Assignment. Review Compass Laying. Prepare necessary instruments for day's work.

3. **Field Work.**
Smoke Bomb Practice.

4. **Field Work.**
Field Computation of Firing Data and Use of B. C. Instruments.

Note—(Use all B. C. instruments, paying close attention to proper use of hands in making adjustments. Ask questions about parts, principles, and nomenclature.)

5. **Field Work.**
Smoke Bomb Practice.

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6. **Test.**
Nomenclature and use of Fire Control Instruments, personal adjustments.

Note—(Have a set of questions for each two sections. Cover only nomenclature.)

7. **Conference.**
Field Firing and Terrain Board.

Note—(Discuss the duties of different officers in field firing. Take up the variation to be expected in firing and importance of fire discipline. On terrain board, take up special study of height of bursts and cross fire. Include some work in corrections for individual pieces.)

Assignment. Pars. 1438–1463, D. & S. R. F. A.

8. **Field Work.**
Field Computation of Firing Data.

9. **Conference.**
Terrain Board.

10. **Field Work.**
Smoke Bomb Practice.

11. **Test.**
Principles of Fire.

Twelfth Week—(10 hours).

1–10. **Field Instruction in Camp.**

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DISMOUNTED DRILL AND MILITARY COURTESIES

First Week—(6 hours).

1. **Drill.**

Formation of Battery. Par. 151.

Note—(Have men fall out promptly at the signal for formation; ranks should be quickly formed and dressed to the right; proper intervals and distances obtained by insisting that candidates bring up the left arm and catch the line to the right, so that at the command "FALL IN" there will be no confusion, and no time lost. They should be assigned their proper places in ranks so that "Counting Off" will be unnecessary. Later when they are familiar with their positions in ranks "Counting Off" should be discontinued. Practice "Call Rolls" and "Report." Chiefs of Section should be instructed to complete the salute, then report.)

Open Ranks. Par. 152.

Note—(Be particular that rear rank drops back four steps only, arms brought to right dress with precision, head and eyes turned to the right smartly. At the command "FRONT" arms are brought down with a snap, and all heads and eyes turned to the front smartly. Demand this smartness in all formations.)

Close Ranks. Par. 153.

Note—(Rear rank takes two 30-inch steps forward.)

Right (Left)Dress. Par. 98.

Note—(Execute the movement until it is done correctly; all arms, heads, and eyes moving with smartness, fingers extended and joined, palm on the hip, thumb along the forefinger, elbows in ranks. At the command "FRONT" heads and eyes are turned to the front with a snap, and arms are brought down smartly.)

Count Off. Par. 97.

Note—(This movement is often allowed to be done in a sloppy, slovenly way, and by insisting upon a snappy execution at the beginning, corrections will be unnecessary later. Insist that at the command "COUNT OFF" all heads are turned smartly to the right, and as soon as the candidate has counted his number, he turns his head to the front smartly. Do not tolerate a ragged execution; when counting lags, stop the count and start over again.)

To Form the Squad. Par. 97.

Note—(Take eight men, have them assemble in front of Section, demonstrate with them the formation of the squad. Have this squad execute "FORWARD MARCH," "HALT," "SQUAD RIGHT (LEFT)," "SQUAD RIGHT (LEFT) ABOUT." Illustrate these movements by moving men individually to their places, and calling out their numbers. Take Section in line, and give "Squads Right," see that all men take their specified places, have Section halt when squads have arrived in column. See that each man is in his proper place. Move Section into line again and halt.)

Assignment. Pars. 97–98, 151–153.

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2. **Drill.**

Position of Attention. Par. 68.

Note—(Explain and demonstrate the position in detail with the Section at attention, pass down line and make individual corrections. Impress upon the candidates the necessity for thumbs along the seams of breeches, with back of hands turned outward. This aids to throw the shoulders back and arch the chest.)

Rests. Par. 72–74.

Note—(Insist that when assuming the position of attention all tendency to move in ranks ceases.)

Eyes Right (Left) Front. Par. 75.

Note—(Explain the necessity for precision in this movement. Turn the head and eyes sharply to the right without moving the shoulders. At the command "FRONT" snap the head and eyes smartly to the front.)

Facings. Pars. 76–77.

Hand Salute. Par. 78.

Note—(Insist upon the proper positions and let no error pass without correction.)

Steps and Marchings. Pars. 79–95.

Note—(Use squad in front of Section, to teach regulation steps and cadence. Demonstrate "DOUBLE TIME." Be careful not to execute too long a stride, and see that the proper position of the arms is adhered to.)

Assignment. Pars. 68, 72–95.

3. **Drill.**

Alignments. Pars. 98–99.

Note—(The squads have already been taught to dress. Explain the necessity for proper interval and regulation distance between ranks. Explain the guide, both right and left, and show that it is always right unless otherwise specified.)

To Take Intervals and Distances. Assemble. Pars. 100–107.

Note—(Have ranks count off and go through the movements. See that all files keep covered and dressed. Insist that this movement be executed with precision and exactness.)

Oblique March. Pars. 108–109.

Note—(This movement is one of the hardest for new troops to execute properly, and great care should be taken to see that the instruction is given correctly. Demonstrate by having squad go through the movement in front of Section. Align squad, give right half face, march squad in this oblique direction, insisting that files keep covered in both directions.)

Commands. Pars. 48–51.

Note—(At this point in the instruction demonstrate and explain commands. Let sections give commands in unison. Pay particular attention to tone and volume of voice. Show that volume is proportioned to size of command. Give rising inflection in the preparatory command, and make the command of execution short and snappy.)

To Turn on a Moving Pivot. Par. 110.

To Turn on a Fixed Pivot. Par. 111.

Note—(Demonstrate with squad the position of each individual in the turns by moving the candidates separately to their places and calling attention to their numbers.)

Assignment: Pars. 48–51, 98–99, 108–111.

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4–5. Conference and Drill.

Assignment: Chap. 1, Vol. 1, N. C. O. Manual.

6. Test.

Second Week—(5 hours).

1. Drill.

Squad Movements.

Facings.

Steps and Marchings.

Posts of Officers and Noncommissioned Officers. Pars. 149–150.

Note—(Post the Officers and Noncommissioned Officers, use several details of candidates so that all candidates will be familiar with the formations and posts.)

Maneuvers of the Battery. Pars. 156–160.

To Form and March in Column of Squads. Par. 161.

Note—(In marching see that the regulation 40 inches distance is kept and that all files are covered from head to rear and dressed in each rank. Accustom the candidates to marching without counting the step. Explain that to keep the step in column of squads it is necessary to keep their heads up, look ahead, and learn to catch the step from the swing of the shoulders of the men in front. When it is necessary to count step, do it briefly, it is bad to count for long periods, for it makes the men dependent upon the counting.)

To Change Direction While in Column of Squads. Par. 162.

Note—(Insist that candidates march squarely up to the turn; obliquing in on the turn is the principal error to be corrected in this movement.)

Assignment: Pars. 156–162.

2. Drill.

Review. Take Intervals and Distances.

To Form Column of Squads and Change Direction. Par. 163.

To Form Line from Column of Squads. Pars. 164–166.

To Form Flank Column of Files. Pars. 167–168.

Route Order and At Ease. Par. 169.

Note—(Have candidates assume a position when at ease with hands clasped behind back and feet about twelve inches apart.)

Assignment: Pars. 163–169.

3. Conference and Drill.

4. Drill.

March Section in Column.

Note—(Marching section in column has no particular disciplinary advantage, it is best to march the section a few steps forward and halt, and continue in this manner.)

March Section in Line.

Note—(Change direction of guide from right to left, and left to right. Halt section in line and let candidates see where their faults are. Explain to candidates the proper method of keeping their alignments when marching in line. If distances and intervals are lost they should be regained gradually and slowly. Explain

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that if one man attempts to regain his proper position by a quick movement it will throw out the whole line.)

March Section at the Oblique.

Note—(Halt section in place and resume march. Halt section and insist that all face to the front on the same count.)

Review. Pars. 161–166.

Mark Time and Halt.

Note—(In giving the command "HALT" be careful to see that the command is given at the instant one foot strikes the ground.)

Assignment: Pars. 161–166.

5. **Drill.**

Practice Giving Commands.

March Section in Quick and Double Time.

Halt from Quick, Double, and Mark Time.

Steps and Marchings.

Turn on Fixed Pivot.

Turn on Moving Pivot.

Change Step.

Third Week—(5 hours).

1. **Conference and Drill.**

2. **Drill.**

Note—(Form section quickly, change the position of the guide and have the section fall in on new line; this practice gives excellent training for forming line smartly. Teach candidates to move quickly.)

Recruit Instruction. Pars. 67–94.

Assignment Pars. 67–94.

3. **Drill. Pars. 95–114.**

4. **Drill.**

Maneuvers of the Battery. Pars. 156–159.

5. **Conference and Drill.**

Fourth Week—(6 hours).

1–5. **Drill.**

Maneuvers of the Battery. Pars. 156–159.

6. **Test.**

DRILL OF THE GUN SQUAD

The schedule for "Drill of the Gun Squad" as taught at the F. A. C. O. T. S. has been incorporated with immaterial changes into the chapter on that subject in this book.

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DRIVING

(a) Harnessing and Unharnessing and Adjustment of Harness.

First Week—(2 hours).

1. Conference. Wooden Horse.

Nomenclature of Harness. See Ordnance Handbook, pages 144–149, inc. show steel collar (its adjustment), Plate xxvii, Ordnance Handbook. Illustrate adjustments on wooden horse. Draw chalk lines showing shoulder, center of motion of shoulder, of horse, showing point of buttocks and point of shoulder blades. Show rough hand adjustment for position of saddle, position of breeching side straps and backstraps and tightness of cincha. Bring out all points of adjustment of bridle, traces, backstrap, side strap, crupper, etc. Use both breast and steel collars.

2. Field Work.

Actual adjustments by candidates in the field. Instructors will assemble sections and go over adjustments made by the candidate. Let candidate explain to the class what tests and adjustments he made. Allow twenty minutes for candidates to go over harness assigned to them, rest of time for inspection of same.

Second Week—(2 hours).

1. Field Work.

Same as second lesson, first week, assigning candidates to different pairs, keep roster so that candidates will get wheel, swing, and lead horses.

2. Drill.

Same as second lesson, first week, changing candidates so that they get new pair; in first weeks use breast collars.

Third Week—(3 hours).

1. Field Work.

Same as second lesson, first week, using steel collars. Pay particular attention to holding up and holding down straps. Impress upon candidates necessity of getting horses in draft to determine line of pull perpendicular to line of shoulder.

2. Field Work.

Same as first lesson, third week. Demonstrate ill effect of having horses in draft without holding up and holding down straps properly adjusted. Show line of pull, with straps properly adjusted. Loosen straps on one team and have that team drive in front of assembled candidates with the brakes on, so that all horses will be in draft.

3. Field Work.

Harnessing and unharnessing in the field. By detail. Instructor and two assistants unharness and harness one section, going through each step carefully and explaining each step and proper method of doing it. Show position of harness

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on pole, reason for it (to have uniform method throughout your battery). Explain method of tying on wheels, manner of hooking and hitching. Caution: do not remove martingales from pole yoke but unhook side straps. Safe on martingale goes next to horse's belly.

Assignment: Pars. 405, 406, 408, 411, 413, 414, 415, 425, 433, 434, 435, 436, 438, D. & S. R. F. A.

Fourth Week—(3 hours). Field Work. Assignment: Same.

1. Candidates harness and unharness by detail. Have candidates stand to heel after completion of each detail. Have all candidates complete each detail before proceeding with the next.

2. Same. Finish the entire harnessing this time.

3. **Unharness and Harness—not by detail.**

Lecture

On evening preceding beginning of course, including moving pictures 12, 13, 14, 15, 16, and 17. School of Soldier.

(b) Driving Drill, Signals, and Draft.

Note—(All candidates will report without whips and spurs until last week.)

Fifth Week —(3 hours).

1. **Drill.**
   Dismounted.

Instruction in all arm and whistle signals, formation and execution of movements prescribed for the battery mounted (504–548).

Note—(Candidates should first be required to form as for semaphore drill and to go through each arm signal. They should then be formed by threes in column of file, each man of each set of threes acting as a pair in hitched team, leading man the lead pair, second man swing pair, and last man wheel pair. These sets of threes should be formed as a battery mounted and put through movements keeping normal distances and intervals, chiefs of sections and caisson corporals giving proper signals. In this way by changing chiefs of sections and caisson corporals, all candidates will get practice in giving signals and in movements. Make candidates pay attention. Teach them always to glance toward B. C. when whistle is blown, and watch for signal. Instructors will be careful to allow candidates plenty of time to see signals and enough interval between preparatory command and that of execution to allow them to think how to execute it.)

Assignment: (504–548).

2. **Same.**

3. **Test.**

Sixth Week—(2 hours). Drill.

1. **To Stand to Horse. 425. The Guides. 431. Rests. 432. Managing Pair. To Mount and Dismount.**

Note—(All further instruction will be mounted.)

The same care as to seat and hands of candidate while mounted should be taken in this instruction as in the riding instructions. It is expected in the first three hours that all signals and movements under pars. 504–548 shall be covered so that from the beginning of instruction in driving with teams hitched, each

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candidate will be thoroughly familiar with all signals, the manner of executing each movement and the gaits at which they are executed. Pairs in column, traces unhooked.

Assignment: Rules 1 and 2 (519). Pars. 425, 431, 432, 444, 519, and 423.

2. Management of pairs. Review first lesson sixth week including pairs in column, traces unhooked, 448.

Assignment: Pars. 504–548, D. & S. R. F. A.

This drill to be conducted at a walk.

Seventh Week—(5 hours). Drill.

1. Review second lesson of sixth week. To hook the traces, 433. Include traces hooked with teams unhitched. 449.

Assignment: Par. 433–439, 504–548, D. & S. R. F. A.

2. Driving: have Teams Hitched.

To start a carriage or increase its speed, 452. To stop a carriage or reduce its speed, 453. To back a carriage, 454. Turns.

Note—(This drill to be conducted at a walk and in section column. With one team hitched, three good candidates should be selected as drivers, all other candidates looking on, and will be required to go through above movements. To start, halt, back, the turns especially should be accurately executed. The instructors should take the wheel team and give practical demonstration how this team may control movements of carriage.)

Assignment: Pars. 452, 453, 454, 504–530, 534, 535, D. & S. R. F. A.

3. All teams are hitched from now on. Work at a walk and same as second hour. Instructors will carefully note and correct all faults of seat, handling of reins and horses, and any mishandling of pairs or teams. Be careful to see that drivers keep near reins in left hand, and the extreme end of the lash of off horse's reins in left hand, with reins of off horse in right hand. To be conducted at a walk in section column.

Assignment: Same.

4. Same. Work at walk. Turns; work in column. Instructors demonstrate limber turn.

Note—(Each day drivers should change pairs so that each will fill the three posts of lead, swing, and wheel drivers. The wheel drivers of one day should go to the swing, swing to the lead, and lead to wheel. Watch especially distances, intervals, and turns.

Assignment: Pars. 455, 530, 535–531–538, D. & S. R. F. A.

5. Section column. To start a carriage or increase its speed. To stop a carriage or reduce its speed. To back a carriage, 454. Turns.

Assignment: Instruction Memorandum No. 9-A and Pars. 504–548, D. & S. R. F. A. Work at walk and trot.

Eighth Week—(6 hours). 1–5. Drill.

1. Battery, 520–522. To halt, 523. To march by the flank, 524, 525. Right by Section, 534. Work at a walk in section column. Work at a trot in section column. Watch distances carefully.

Note—(A roster should be run and details for B. C., chiefs of platoons, first

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sergeant, chiefs of section, etc., should be published the day before in order that students may look up their duties.)

Assignment: Pars. 423, 424, 476, 487, 501–548, D. & S. R. F. A.

2–3. Battery mounted. Same as third hour, eighth week. Work at walk and trot. Section column, also the oblique and passages of carriages. Work at walk and trot.

Assignment: Same.

4. To close or extend intervals, form line from section column, flank column and double section.

5. Battery Mounted. Guides, 508–515. Gaits, 516–519. Movements, 520–548.

Assignment: Pars. 504–548, D. & S. R. F. A.

6. Test.

Ninth Week—(5 hours).

1. **Drill.**

Review. Action Front, 559. Action rear, 560. Action Right and Left, 561. To limber to the front and rear and to march, 562–567. To form double section line after limbering, 568. Work at walk and trot.

Note—(Each new movement should be executed very slowly at first.)

Assignment: Pars. 559–568, 551–558, D. & S. R. F. A.

2–5. Field Work.

2. Driving over difficult ground. This work to be done at a walk.

3. Driving up steep slopes and over difficult ground.

4. Driving through wooded ground at a walk. If no ground is available, assimilate instruction by driving stakes. Have candidates drive between them.

5. Work at the walk. Driving in wooded country, difficult turns, ditches, and gradual slopes.

Tenth Week—(5 hours). Field Work.

1. **Work at the walk.** Driving up steep slopes and down steep slopes. Have drivers keep their heels down and out of horses' sides when going down hill.

2. **Work at the walk.** Same as first hour. Show how to start a stalled team.

3. **Work at the walk.** Driving through deep ditches through the narrow turns, turns on a steep slope. One case where lead driver controls carriage during the turn.

4. Road march one hour.

5. Drill. Battery Drill Mounted. All sections. Work at walk and trot.

Assignment: Pars. 501–568, D. & S. R. F. A.

Eleventh Week—(5 hours).

1. **Field Work.** Driving over difficult ground. Select hard turns in woods. Show candidates how to get out if stuck against any obstacle. Remember to cramp pole toward the object, back up the pair and turn pole away from object, without moving forward and have team move out. This is the simplest way to get out, if stuck against any obstacle.

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2. **Drill. Battery mounted, all sections. Work at walk and trot.**
Assignment: Pars. 501–568, D. & S. R. F. A.

3. **Drill. Rolling Drivers' rolls and packing same.**
Assignment: Chap. XIII, D. & S. R. F. A.

4. **Field Work.** Driving over very difficult ground. Show candidates that artillery can go anywhere it is wide enough for carriages to get through.

5. **Drill.** Drill Battery Mounted and all movements with snap at walk and trot. Graduation drill.
Assignment: Pars. 501–568, D. & S. R. F. A.

Tweifth Week—(10 hours).

1–10. **Field Instruction in Camp.**

FIRE DISCIPLINE

The assignments and questions of the "Daily Questionnaire" in the chapter on "Fire Discipline" cover in the same order the course at the F. A. C. O. T. S.

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GUNNERY

Fifth Week—(5 hours). Conferences.

Note—(Great emphasis on simplicity of statement is required in this course, any complicated mathematical discussion is uncalled for and worse than useless. Drawings and illustrations are used daily and required of candidates. Considerable time must be spent daily preparing candidates for the next day's assignment, otherwise their work will be poorly prepared.)

1. **Definitions.**

Note—(Burst Range, Burst Interval, are measured in the plane of site; designation of crests depends on the situation; that is, on the location of the battery and the target. Do not enforce the learning of definitions verbatim but adhere to the language used in the text. Illustrate on blackboard wherever possible. Be sure that these definitions are clear to every candidate. They are important.)

Assignment: Par. 1044, D. & S. R. F. A.

2. **The Trajectory.**

Note—(Illustrate on the blackboard the trajectory and all its elements with a site greater than 300 and then less than 300, showing the changes. In this work take the opportunity to review the definitions. Keep separate the elements of time and percussion fire.)

Assignment Par. 1044, D. &. S. R. F. A.

3. **The Trajectory.**

Note—(Discuss the trajectory "in vacuo" and in air, showing how the force of gravity, resistance, and rotation affect the flight. Bring out the fact that drift is a function of elevation. Discuss direct, curved, and high-angle fire.)

Assignment: Pars. 1045–1053, D. & S. R. F. A.

4. **Rigidity of the Trajectory.**

Note—(Show that it is an assumption which for all purposes of the field artilleryman may be taken as fact. Use illustrations, such as the idea of the stream of water; make your language simple. Explain the construction of a trajectory without calculation, showing that a short trajectory is simply a part of a long one.)

Assignment: Pars. 1045–1053, D. & S. R. F. A. Hand in drawing showing trajectory, its parts, and angles of importance.

5. **Manipulation of the Trajectory.**

Note—(Range increased by increase of site. Elevation alone affects burst range but not the apparent height of burst. H. of B. dependent on site and corrector. Effect of simultaneous and corresponding changes. Burst range and its dependence on fuse setter. Simultaneous change of site, corrector, and range.)

Assignment: Par. 1054, D. & S. R. F. A.

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Sixth Week—(5 hours). Conferences.

1. **Range Tables for 3″ Field Gun.**

Note—(Discuss and explain the separate columns of the table, their uses, and the sources of the information. Note that the table is correct only for shrapnel. Do not discuss it for use with shell.)

Assignment: Drawings showing changes in trajectory due to manipulations in previous day's work.

2. **Application of Range Tables to Manipulation of the Trajectory.**

Note—(Use range tables to compute the changes in corrector and range necessary to compensate for a change in site, or the reverse. Solve enough problems in compensating changes of this nature to fix clearly the relation between different range table columns.)

Assignment: Drawings illustrating effects of simultaneous changes of site, corrector, and range.

3. **Formulas for Approximate Calculations. Method of Figuring Angle of Departure by Formula and Scale, and Interpolating for Hundred of mils.**

Note—(Give mental problems. Have candidates learn formulas for angle of departure, angle of fall, and distance to maximum ordinate. Use no other formulas. Learn the 1, 2, 3 method of computing the angle of departure.)

Assignment: Formulas, with one simple problem under each.

4. Note—(Review work of week and give problems.)

Assignment: Pars. 1044–1054, problem or drawing calling for review.

5. **Test.**

Note—(Cover work of week, but do not give long or involved questions or problems. Arrange groups of questions for the different hours.)

Seventh Week—(6 hours). Conferences.

1. Discuss the work of previous week and the test of last hour. Review definitions.

2. **Influence of Atmospheric Changes and Wind on the Trajectory.**

Note—(Explain the barometer. Discuss effect of temperature changes with a constant pressure and of pressure changes with a constant temperature. Explain normal pressure and temperature of the seasons. Discuss effect of wind on range, using theory of constant time of flight. Discuss the "Normal corrector." Effect of changes on time of burning, and consequently on height of burst; first for pressure and then for temperature.)

Assignment: Par. 1225, F. A. D. R. Drawing illustrating changes.

3. **Shrapnel Action. Cone, apex, angle of opening, pattern, and effectiveness.**

Note—(Review work of the previous hour.)

Assignment: Pars. 1044–1051–1053. Drawing of Cone, showing apex, angle of opening, axis, and pattern or base.

4. **Dispersion.**

Note—(Discuss and explain the phenomenon of dispersion. Keep your explanation simple. Use illustrations. Do not let the candidate confuse shrapnel action with dispersion. Give clearly the fundamental causes of dispersion,

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variation in charge, and projectile, action of mount, irregularities in laying. Distinguish carefully between dispersion and variation of the center of impact.)

Assignment: Par. 1044, Burst Interval, Deflection Counter, Height of Burst and Counter, Mean Height of Burst, Center of Impact, Range of Burst Center.

5. Note—(Review thoroughly the work of the week.)

Assignment: Draw shrapnel pattern on (a) Horizontal plane, (b) Counter slope, (c) Reverse slope.

6. **Test.**

Eighth Week—(5 hours). Conferences.

1. **Probable Error.**

Note—(Explain errors as common to everything, show what the mean error is and how the probable error is a refinement of the mean. Make your statements clear and simple and do not become involved in any unnecessary discussion. Discuss the 3″ Handbook probable error table and explain E. P. for range, deflection, height of burst.)

Assignment: Par. 1044. Probable error. Problem requiring calculation of the average, the mean, and four quarters (quartiles) of 25% each. Place range tables on bulletin boards of each section and give problem requiring comparison of probable errors.

2. **Dispersion Diagram.**

Note—(Build up and explain the dispersion diagram and its application to problems of ammunition expenditures.)

Assignment: Drawing to show Center of Impact, Par. 1044.

3. **Application of Dispersion Scale to Solution of Problems.**

Note—(Give simple problems to start with and explain the solution of each carefully. Have candidates put solution on board and explain. Never leave a problem until every man has expressed his understanding of it.)

Assignment: Have each man make a dispersion scale, two directions.

4. **Two-dimension Problems.**

Note—(Explain the two-dimension problem. Continue to have students work at problems in conference.)

Assignment: Two problems based on dispersion scale.

5. Note—(Continue work of the previous hour. Explain solution when center of impact is not at center of target.)

Ninth Week—(6 hours). Conferences.

1. **Same as Previous Hour. Problems.**

Assignment: Two problems involving scale. Center of Impact not in center of target.

2. **Explain Three-dimension Problem.**

Note—(Work by changing third dimension, vertical, to range dimension by use of slope of fall. Illustrate. Then solve as two-dimension problem. Give simple problem.)

Assignment: Problem in changing vertical wall or target into horizontal target, using slope of fall.

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3. Same as Previous Hour. Assignment: Problem, three dimensions.

4. Application of Principles Learned to Drill Regulations. Pars. 1207, 1208, 1212, 1217, 1222, 1243, 1259, 1296, 1308, 1309, 1311, 1314, 1319, D. & S. R. F. A.

5. Application of Principles to Drill Regulations.

Note—(Continue discussion of the last hour, asking questions of candidates as to application of principles to paragraphs discussed.)

Assignment: One Problem in three dimensions.

6. Test.

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MATÉRIEL

Note—The numbers given below refer to pages in the Handbook of the 3-inch Gun Matériel.

Candidates will submit drawings or diagrams as indicated in the table to the instructor in Matériel. The drawings may be copied from those in the handbook or pamphlets. Names of various parts will be entered.

DRAWING	REFERENCE	DAY TO BE SUBMITTED
Elevating and traversing mechanism, 3-inch gun	3-inch Handbook.....	Second Saturday
3-inch Shrapnel, 21-second combination fuse.....	3-inch Handbook.....	Third Saturday
3-inch recoil system.....	3-inch Handbook.....	Fourth Saturday
British 75mm. recoil system.....	British 75 mm. Gun Matériel Handbook.....	Sixth Saturday
Panoramic sight (Model of 1904).....	3-inch Handbook.....	Seventh Saturday

First Week—(6 hours). Field Work.

1. Description and nomenclature of the limber and caisson (Model of 1902); gun carriage including trail, pintle, and lunette (67, 68, 71, 75–77, 88–101).

2. Description and nomenclature of the limber and caisson (Model of 1916) (101–115). Review nomenclature of the gun carriage.

3. Description and nomenclature of wheels and fastenings (77–78). Description and nomenclature of cradle and rocker (67–68). Explanation of all parts of the gun in recoil and counter recoil (70–71).

4. Review the action of all parts in recoil and counter recoil. Description of the automatic pole support (104–105). Nomenclature of straps and their uses (93, 99, 106).

5. Tools, their uses and places for carrying them (189, 192, 193). Description of the gun proper; elevating and traversing mechanism (22, 72–76).

6. Test.

Second Week—(5 hours). Field Work.

1. Review description and nomenclature of elevating and traversing mechanism. Dismount elevating and traversing mechanism (82–83).

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2. Description and nomenclature of the breech block and all its parts (23–29). Dismantling and assembling same (29–30).

3. Review dismantling and assembling breechblock and all its parts.

4. Description, operation, and dismantling the firing mechanism (29–30).

5. Remove pole, wheels, and hub liner (84–91). Description of road brake and its adjustment (84–91; 77, 83).

Third Week—(6 hours).

1–2. Conferences. Description and nomenclature of ammunition and fuses (34–46). (Explain the American common shrapnel, 21 second and both percussion fuses.)

3. Conference. Lecture: Care and handling of ammunition.

4. Field Work. Description, nomenclature, adjustment, and dismantling the bracket fuse setters (Models of 1905M and 1916).

5. Field Work. Description, nomenclature, adjustment, and dismantling the hand fuse setters (Models of 1905M and 1912).

6. Test.

Fourth Week—(Three 2-hour periods). Field Work.

1. Dismount rifle and recoil mechanism (78–82).

2. Review dismount rifle and recoil mechanism.

3. Entraining and detraining matériel, using a 40-foot car (187–188; Pars. 1728–1774, D. & S. R. F. A.)

Fifth Week—(5 hours).

1. Field Work. Entraining and detraining, using a 32-foot car (187–188; Pars. 1728–1774, D. & S. R. F. A.)

2. Conference. Care of leather, canvas, and metal. Oils: kinds, uses, and where carried. Cleaning and care of the wheeled matériel (181–187, 151–153).

3. Field Work. Clean and oil harness.

4. Field Work. Description and nomenclature of the limber and gun carriage, including axletree and wheels, trail, carriage body, cradle, brakes, shield, and recoil mechanism. (Handbook, British 75mm. Gun Matériel, pp. 33, 34, 46, 47.)

5. Field Work. Explain the action of all parts in recoil and counter recoil (same Handbook, pp. 34, 35). Nomenclature of straps and their uses (same Handbook, p. 46). Tools and places for carrying them (same Handbook, p. 107). Description and nomenclature of the gun proper (same Handbook, pp. 10, 11).

Sixth Week—(6 hours). Field Work.

1. Description and nomenclature of the traversing and elevating mechanism; range gear (same Handbook, pp. 35, 36). Dismount and assemble the traversing and elevating mechanism and range gear (same Handbook, pp. 43, 44). Dismount and assemble the cradle and carriage body clamping gears (same Handbook, pp. 44, 45).

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2. Description and nomenclature of the breech block (same Handbook, pp. 11–12). Dismount and assemble same. Description, nomenclature, and operation of the firing mechanism (same Handbook, p. 12). Dismount and assemble same.

3. Remove the pole, wheels, and wheel box (same Handbook, pp. 45, 48). Dismount the gun. Dismount the brake gear (same Handbook, p. 44).

4. Dismount the recoil mechanism (same Handbook, pp. 39, 40). Drain and refill the buffer when in the gun carriage (same Handbook, p. 42).

5. Dismount and assemble the shield and cradle.

6. Test.

Seventh Week—(2 hours). Field Work.

1. Description and nomenclature of battery and store wagon. Pack same. (130–135, 189–203).

2. Description and nomenclature of panoramic sights (153–164). Description and nomenclature of the quadrant. Dismantling and assembling same (164–167).

Eighth Week—(2 hours). Field Work.

1. Verification of parallelism of line of sight and axis of bore (172–173). Adjustment of the front and rear sights (171). Adjustment of the panoramic sight—Model of 1904 (170).

2. Field Method of verification of parallelism of line of sight and axis of bore. Review adjustment of panoramic sight—Model of 1915 (173, 170).

Ninth Week—(2 hours). Field Work.

1. Pitching shelter tents. (Pars. 1856–1860, D. & S. R. F. A.) Rolling cannoneers' rolls and packing same on the carriages (Pars. 1823–1824, D. & S. R. F. A.)

2. Folding paulins and securing them (659). Attachment of prolonges for use of cannoneers in assisting horses in draft. Stretching the picket line. Review, tent pitching, and rolling rolls.

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RECONNAISSANCE

Fifth Week—(5 hours).

1–3. Conferences.

1. "Artillery Tactics."

2. "The Battery Detail."

3. Formation of the Battery Detail.

Component Groups. Reason for this subdivision. Composition of each group. By whom commanded. Signal use by B. C. in calling for detail (1595). How the Detail calls off (1595). How an officer should give orders and instructions (1505–1516).

Assignment: Pars. 1597–1600, 1534, 1626, D. & S. R. F. A.

4–5. Drill.

4. Review formation of the detail. Route Marking (Pars. 1597–1600, 1534, 1626, D. & S. R. F. A.)

Note—(The instructors should have chosen previously a typical battery position. He will cause a route to be marked to this position by the relay method. He will cause his section to return to the park, marking the route by connecting files.)

Assignment: Pars. 1601, 1648, 1602, 1609, D. &. S. R. F. A.

5. Review formation of the Detail and Route marking. How to approach a position. (Pars. 1601, 1648.) Horse holding; duties of Bugler No. 1 (1602, 1609); duties of Instrument Driver and Horse Holder No. 1. Methods used in leading off and controlling led horses; use of link straps.

Assignment. Pars. 516, 1604, D. & S. R. F. A.

Sixth Week—(5 hours).

1–2. Drill.

1. Review formation of the detail, route marking and horse holding. Gaits for Field Artillery (516). How to cross railroad tracks and bridges. Information a B. C. should give Instrument Sergeant and Signal Corporal.

Note—(The review should be conducted not by quizzing but by performance. In the assignment for the day, the acting B. C. should be required to give instructions to his Instrument Sergeant and Signal Corporal, assuming target, sector, reference points, mission, etc.)

Assignment: Par. 1607, D. & S. R. F. A.

2. Review as before. The Gun position; gun markers' duties, Par. 1607, D. & S. R. F. A. Position of led horses.

Assignment: Pars. 1548, 1065–1067, 1064, D. & S. R. F. A.

3. Field Work. Gun positions (1548). Defilade (1065–1067). Positions for immediate action, etc. (1064).

Note—(The Instructor should point out the desirable characteristic of the position he has been using on the actual ground.)

Assignment: Pars. 948, 1592, 1610, 1651, 1608, 1649, 1556 D. & S. R. F. A.

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4. Drill. Duties of executive (948, 1592). What he should do in approaching a position (1610). Methods of putting battery in position (1651). Duties of First Sergeant (1608, 1659, 1556).

Assignment for next period. Pars. 1095–1104, 1129–1135, 1519, 1534, 1611, 1615, 1116, 1123, D. & S. R. F. A.

5. Conference. Communication. See assignment above.

Seventh Week—(5 hours).

1–2. Drill. How communication is established (1095–1104, 1129–1135, 1519, 1534, 1611, 1615). Extension of line (1116, 1123). Use and duties of line guards, use of reserves, alternative communication. Transmission of firing data, (52, 53, 1124).

3. Field Work. Designation of targets, reference points, sectors, etc., (1144–1152).

4–5. Drill. Same as 3.

Assignment: Pars. 1531, 1532, 1646, 1132, 360, D. & S. R. F. A.

Eighth Week—(7 hours—two 2-hour, three 1-hour periods).

1. Conference. Agents (1531–32, 1646, 360.)

2–3. Drill. Agents. Sending and delivering messages. How a messenger should deliver a message. Standard form for messages. Gaits for agents.

Assignment: Pars. 1071, 1093, 1228–1234, 1517–1519, 1525–1530, 1582–1592, 1633, 1645, 1666, D. &. S. R. F. A.

4. Conference on Scouts. Assignment above.

5–6. Drill. Scouts, their duties and uses. As forward observers. As flank observers. In security. In forward reconnaissance. Reconnaissance of routes and positions, road reports.

Assignment: Pars. 1518, 1525–1527, 1529–1530, 1516, 1546, D. & S. R. F. A.

7. Conference on assignment.

Ninth Week—(7 hours—three 2-hour periods).

1–2. Drill.

3–4. Same as 1–2.

5–6. Same as 1–2.

7. Test.

Tenth Week—(5 hours). Conferences.

1. Replacement of Casualties and B. C. Detail. Resupply of Ammunition. 1033–1038, 1040, 1707.

2–5. Review any subject concerning the battery detail in which the sections are weak.

Eleventh Week—(6 hours).

1–5. Conferences. Review problems.

Twelfth Week—(5 hours).

1–5. Field Instruction in Camp.

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TOPOGRAPHY AND ARTILLERY BOARDS

First Week—(2 hours).

1. **Conference:** Military Topography. Maps, their purpose and uses for the artilleryman. Direction, distance, and elevation. Scales, American and French. Sketches, area, place, position, outpost, road, panoramic.
2. **Conference and Field Work:** Conventional Signs, U. S. A., and French.

Second Week—(2 hours).

1. **Field Work:** Orienting the Map.
2. **Conference:** Use of the Engineers' Mapping Kit. Slope Boards, the Leveling Alidade.

Third Week—(2 hours).

1. **Conference:** Stride Scales, their construction and use.
2. **Field Work:** Construction of stride scale over a measured course.

Fourth Week—(4 hours, two 2-hour periods).

1-2. **Conference and Field Work:** Traverse and intersection.
3-4. **Conference and Field Work:** Resection, Two- and Three- Point Method.

Fifth Week—(3 hours).

1. **Conference:** Contours and Hachures.
2. **Field Work:** Filling in contours from critical points—20-foot V. I.
3. **Field Work:** Filling in contours from critical points—5-foot V. I.

Sixth Week—(4 hours).

1. **Conference:** "Visibility," Profile Method.
2. **Field Work:** Make profiles on co-ordinate paper.
3. **Conference:** Construction and Use of the Slope Scale.
4. **Test.**

Seventh Week—(3 hours).

1. **Conference:** Panoramic Sketching.
2. **Field Work:** Make Panoramic Sketch (1 hour).
3. **Field Work:** Make Panoramic Sketch (30 minutes).

Note—(Use the remainder of the hour in pointing out the errors and showing how they may be remedied.)

Eighth Week—(7 hours). Field Work.

1-2. Begin Area Sketch.
3-4. Complete Planimetric Detail.
5-6. Put in contours.
7. **Test.**

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Ninth Week—(7 hours).

1. **Conference:** The Grid System.

2–3. **Field Work:** Make map of hidden and visible areas using the profile method.

4. **Conference:** Reading Coördinates.

5–6. **Field Work:** Complete map of invisible area and make Panoramic Sketch from the point from which visibility was computed.

7. **Conference:** British Coördinate System.

Tenth Week—(6 hours). Conferences.

1. Dead Space.
2. Compute dead areas on the map.
3. Complete computation of dead areas.
4. The use of maps showing hidden and visible areas, dead spaces, and panoramic sketches, in assisting the staff in placing batteries, observation stations, and observation balloons.
5. Italian Resection.
6. **Test.**

Eleventh Week—(5 hours).

1. **Conference:** Location of gun in a defiladed position by traverse and resection.

2. **Field Work:** Demonstration of method. Candidates to locate the coordinates of gun position.

3–5. **Conferences.**

3. The Orienting Line, General control point.
4. The battery in base deflection.
5. The barrage.

Twelfth Week—(5 hours).

1–5. **Field Instruction in Camp.**

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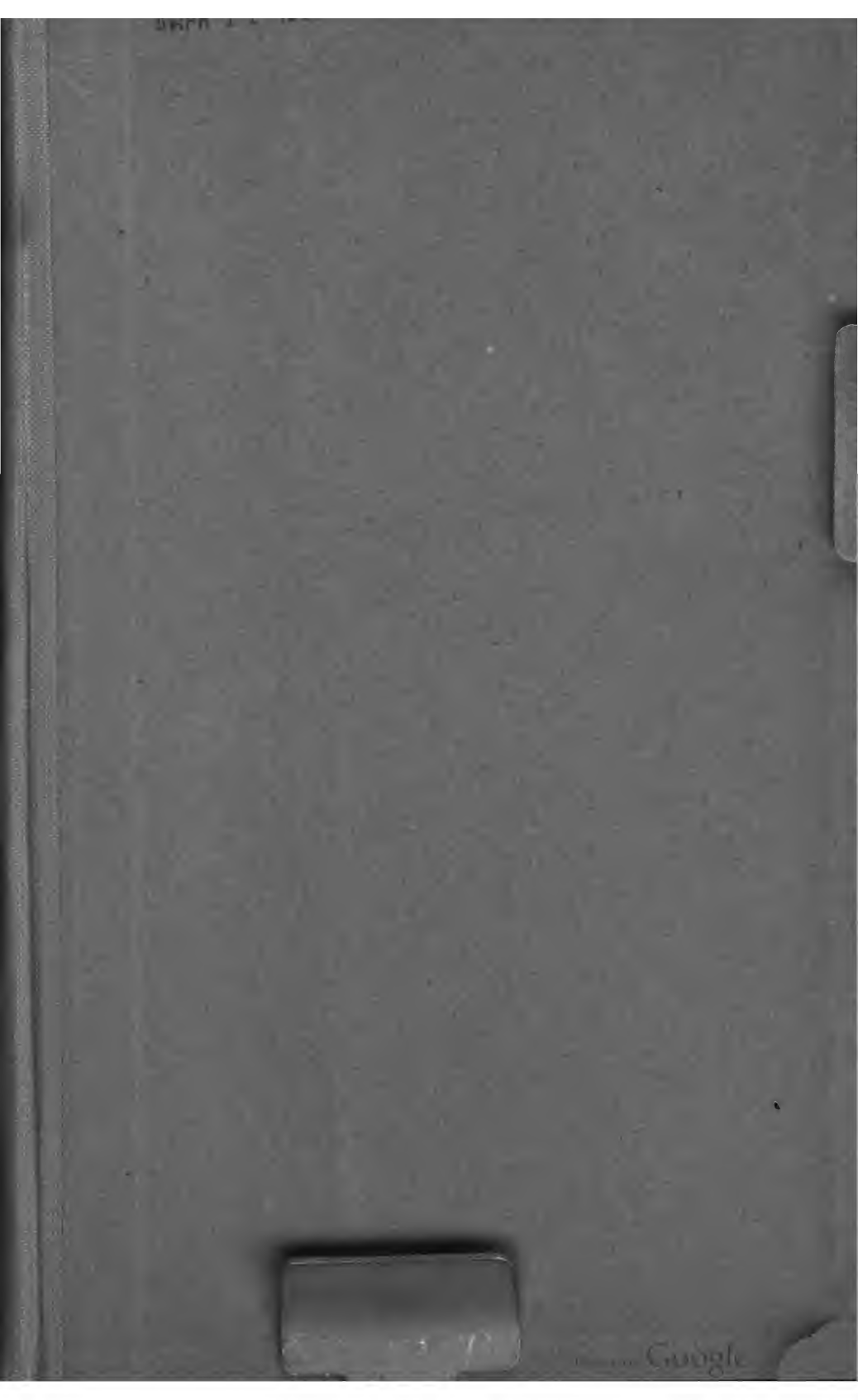
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